

THE MARS FRONTIER

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Mars and Beyond

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1.

Operating Close to the Edge

Dec. 26 2070- Jan. 2, 2071

The phone refused to stop ringing. Will Elliott finally opened his eyes and glanced at the chronometer: 5:30 a.m. Only an hour before he planned to get up, but his body ached at the thought of losing that last hour.

He dragged himself from bed and pushed the “audio only” icon. “Hello.”

“Will, this is Jacquie. Sorry to wake you so early, but there’s big news. The U.S. Attorney General has just announced indictments against former President Knight, former Vice President McKay, and former Secretary of State Vanstone.”

“Really? On what charges?”

“Crimes against humanity.”

“You’re kidding!” Will laughed in amazement. “Incredible! And Mennea did it when; the day after Christmas?”

“With a weekend coming up and Congress adjourned. But he’s been building Congressional support for this for weeks. In two weeks a new Congress is sworn in and it will certainly support this move.”

“The trial will be finished by fall, when the Presidential election campaign starts. I should congratulate President Mennea.”

“That’s why I called.”

“I’ll take a shower and think about it, then put something together.”

“When you get out of the shower check your email; I’ll send talking points.”

“Thanks, Jacquie. I’ll send you a video draft. Bye.”

“Bye.”

Will closed the line and turned to Ethel. She had gotten up and opened the BBC on her tablet. “Unbelievable,” she commented. “They really did it.”

“It’ll resolve most of the complications with the Grand Union. The Belgian indictment can be dropped if an American court finds them guilty.”

Ethel pointed to the article she was reading. “You should hear the scatological response by Knight and Vanstone! It’s shocking.”

“It tells you about their character. I’ve got to jump into the shower.” Will pulled off his clothes and stepped into the bathroom. As warm water coursed over his body he thought about the situation in the United States, the situation faced by its President, and what he should say.

By the time he dressed it was almost 6 a.m. Before turning to Jacquie’s talking points, he called Mike Tobin. His son in law answered without video. “Good morning.”

“Mike, I have to cancel our jog to the top of Layercake Mesa this morning. Political emergencies. The Attorney General of the U.S. has indicted Knight, McKay, and Vanstone on crimes against humanity.”

“Really? Wow! We’ll be sure to tune in.”

“The BBC article’s fascinating. We can do it morrowsol; this won’t last.”

“Alright. Morrowsol I’m at the university all day, so my schedule’s flexible.”

“I thought you were at fabrication all day on Tuesols?”

“No, that’s cut back to just Thursols now; one sol per week.”

“The emergency’s waning. Good. See you tomorrow, then.”

They exchanged goodbyes and Will closed the line. He read Jacquie's talking points, which overlapped with his. He fleshed them out, then hit record. "Good day, President Mennea. Congratulations on the bold move to indict the former president, vice president, and secretary of state on war crimes. It was not easy; they occupied positions of trust for the American people and were members of your political party. But justice demands that this be done. The entire world is watching. Humanity lives in a small neighborhood; everyone can now look into each other's house.

"I will pray that this action is greeted positively by the American people and that it strengthens efforts to bring America into the Grand Union. Best wishes in riding out the storm. Good bye."

He reviewed the message, which was very short and did not require further editing, so he sent it and copied the Cabinet. "Now I regret that I canceled my run with Mike," he said to Ethel. "Shall we go to the Gallerie and have some breakfast?"

She smiled. "Sure!"

They strode together hand in hand to Andalus Square and entered the Gallerie. There they spotted Roger and Érico sitting together and debating. They grabbed some breakfast and joined them. "What a glorious day for a debate!" said Will.

Érico laughed. "We just sat down. We haven't started!"

"Thanks, Will, for the expansion of the exploration staff and authorization for the Hellaspontus expedition," said Roger. "The timing's perfect. A lot of people are itching to get out in the field."

"The emergency's waning every sol. Seven weeks, seven launches: 140 tonnes of cargo on its way. With the gas core engine we can fling cargo around the sun and get it

here in six months even though it's conjunction; who would have thought that would be possible!"

"I'm glad we can get cargo on the way to Saturn in a few weeks," said Érico, who was director of the Saturn Commission's Mars operations. "They really do have urgent needs for some parts."

"We're glad to do it." Will sat at the table with them. "What do you think of the news?"

Ethel frowned at him, knowing he was intentionally starting an argument between Roger and Érico. But both men were happy to take the bait. "The United States is growing up," replied Érico. "It's no longer behaving like a swaggering teenager who thinks he can bully the other kids. It has needed to get off the high horse and behave like a normal country."

"Yeah, right," replied Roger. "People complain the United States is dominating the world until they want the U.S. to do something; then they ask the U.S. to lead! We're bigger than everyone and have special responsibilities to the world."

"Including not being arrogant, and listening," said Érico.

"And how often does Brazil listen?"

"We've gotten pretty good in the last thirty years. That's why Latin America has pulled itself together, formed a common currency, and joined the Grand Union; Brazil was large enough to lead and small enough to consult."

"Maybe." Roger turned to Will. "My fear is that the U.S. is moving too fast. Consider the last four decades of the twentieth century. The sixties saw a vast change where race relations was concerned and that was followed by women's right to choose

and then by gay rights. But all three generated a huge backlash and a conservative mood that dominated politics for decades. The America firsters can't just be vanquished and made to go away. The last half century has been dominated by the issue of globalization, and the fires of conflict have temporarily pushed the public into a more internationalist position. I see the America firsters coming back and being a pain in the ass for the Grand Union, and for American involvement in the Grand Union, for several decades."

"Assuming the U.S. joins; the negotiations have been slow," said Ethel.

Roger nodded. "True, but putting Knight on trial resolves most of the problems."

"As President Johnson observed about appointing a critic to his administration, it's better to have them on the inside pissing out than on the outside pissing in," said Will.

"Except the Grand Union is going to have them on the inside pissing in, not out," observed Érico. "You have a peculiarly isolationist country, Roger."

Roger shook his head. "No, not at all. I think most of the people of the world don't think beyond their own countries much, even in this era of globalization. But in a big country you can hide from the world more than in a little country. The U.S. is no longer big enough to hide from globalization. Half the economy was dependent on it before the war; that's why the fall was so great. The people on both coasts live in economies totally dependent on the global economy and the people in the middle are more dependent than they think. The U.S. is no longer white, either; it's brown and black as well. More Americans were traveling overseas than ever before, right before the war. So the country's not as isolationist as you think."

"Then how do you explain the America firsters?" asked Érico.

"They're a quarter of the country, but a very loud and pushy quarter."

“I think this is a good time for the U.S. to join the Grand Union,” said Will. “The American, European, Indian, and Chinese economies are all roughly the same size and the Latin Union’s economy is half as large as the others. The blocks are all very equal in power.”

“And the economies are all beginning to improve,” added Ethel.

“The banks are stabilizing and employment should start to build again,” agreed Érico. “Even the capitalist-socialist arguments seem to be muted right now.”

“What do you Bahá’ís call it?” asked Roger. “The Lesser Peace?”

Will nodded. “I think so. The time has come when the governments of humanity have come to a mutual agreement about an international structure.”

They chatted a few minutes more, then Will rose to head for his office. He kissed Ethel goodbye on the steps of the Commonwealth Building and hurried inside. Huma was there early, setting up his tea and coffee. “You already have a reply from President Mennea,” she said.

“Really?” Will turned to the tablet on his desk and clicked on the icon prominently visible on the screen. “Thank you, Mr. Chief Minister, for your warm message, and for your best wishes that I ride out the storm! I’ll need that; the tempests are already blowing. But I have been carefully laying the foundation for this day for most of a year, and the election showed that the American people were ready. Your principled messages have been an inspiration to me; you are right that today, we are all each other’s keepers, and it is in the best interest of the United States to be a faithful and responsible steward. I am confident justice will be done. The evidence against my predecessor is overwhelming. Once America acts with justice, it can put the terrible incident into its past

and move forward arm in arm with the rest of humanity. Thanks for reminding us of that.”

The methane fog seemed thicker than usual when Teresa Alvaro, Marshall Elliott, Shiyoko Takashima, and Adel Mehmetoglu set out in Titan’s dawn murkiness for the flanks of Likoma Facula. The ranger moved forward quickly along Likoma Trail, which they had plowed into a smooth, flat road surface over the months as they explored westward.

As they approached the Paricutin thermal complex on the facula’s northwestern slopes, the fog lifted completely, followed by a different type of mist. “It’s amazing how different water and methane fogs are,” commented Shiyoko, their chief engineer, who was making her first trip to a thermal field to scout out its electrical production potential.

“The difference isn’t caused by the substances, but by their states; liquid versus solid,” replied Teresa.

“Oh, of course! The thermal field produces snowfall!” Shiyoko replied.

“A slow drizzle; the air is so cold it holds no humidity at all, except whatever the pools inject briefly into it.”

“But the air is heated up enough so that it never has methane fog,” added Marshall.

“The balmiest spot in greater Acheron; a mere minus 160 Centigrade, rather than minus 180!” Shiyoko said, and they laughed.

The rover slowed and Teresa lowered its bulldozer blade as they entered the thermal area. In the month since they had last visited, an eruption had reshaped the

landscape, followed by a meter of fluffy snow fall. Visibility was about two kilometers; Titan's usual orange cast was replaced by wintery white.

They parked two hundred meters from the edge of Paricutin cone and pulled on their helmets and life support systems, then stepped outside. The snow had been washed away by a recent flood, leaving rubbly, black "Tholinstone," as Adel called it. Shiyoko stopped to pick up a loose chunk. Repeated penetration by warm water removed the ice fraction of the crust, leaving a black residue of stony meteorite glued together by tholin tar.

Marshall pointed to an outcrop of tholinstone that had been cracked and flooded with dirty water, producing veins of white, yellow, and brown ice. "It can be really pretty. It's too bad we can't bring it home and use it for building stone!"

"It'd melt," said Shiyoko. "But crushed chondrite with tholin cement works well."

"Here's Paricutin cone," said Teresa, stopping at a spot where they could see the cone well. "Two months ago several of us hiked to the top. It was safer in person than via virtual reality; if there had been an eruption we could run faster downslope than an Android-150! At that time the water inside the cone was close to the top and rising. It had reached the top, slowly overflowed, froze, and built up the rim higher with new ice deposits. That's how these cones form, as growing ice dams around a vent. We dropped an automated probe into the pool to measure temperature and currents. Ultimately, it settled two hundred fifty-three meters down and sent back data for three weeks. Then the water pressure cracked the side of the vent and in less than hour the central pool completely drained away. The lowered pressure caused the water deep underground, in

the tholinstone layers, to boil, and the geyser effect blasted huge volumes of water out for hours. We found the probe about a kilometer that way.” She pointed southward.

Shiyoko laughed. “A kilometer! That was quite an eruption!”

“Some of it was captured by cameras we left here, until they were destroyed,” continued Teresa. “The area outside the cone, before the eruption, had a few small springs; it was one of them that melted a hole in the side of the cone. As you can see, one side of the cone collapsed from the flood. This whole area was icy devastation. And now the pool is slowly forming in the cone again and snow is falling again. The flood flowed twelve kilometers before it froze solid.”

“That’s what this whole facula is, right?” said Shiyoko. “One vent flood and eruption on top of another, with ‘volcanic ash’ snow in between.”

“There are some great outcrops ahead,” said Marshall. “The snow ‘ash’ gets compressed into layers of white ice, with brown or yellow ice ‘lavas’ above and below.”

They headed into a canyon, eroded by the most recent eruption, to examine and photograph the layers and take samples. Then they followed the canyon to the gap in the side of the cone and cautiously followed it through the cone’s ice walls to the inner caldera. They found a steaming pool of water, covered by icebergs, flooding the floor of the caldera and seeping over the ice dam until it froze.

“Watch out, don’t step in it,” cautioned Marshall to Adel, when he got too close.

“Thanks.” Water instantly froze as hard as concrete at 160 below zero.

They watched the water lap over the ice dam, flow a few meters, freeze solid, and repeat the process thirty seconds later. Teresa led them over to a plastic pole they had driven into the ice dam a week earlier. “During nightspan, the ice dam rose 5 meters,” she

said. “At that rate, this cone will be filled with water to 200 meters in 40 8-day periods, or almost a year.”

“It’ll slow down, though, as more water leaks out around the cone,” said Marshall. “If enough of the flow gets diverted elsewhere, the entire caldera will freeze solid and a new cone will form nearby.”

“On the other hand, if the flow speeds up, the ice dam will melt rather than freeze and the lake will drain constantly,” observed Adel. “That’s the case with Pele Cone.”

“The rate of flow does change, too,” noted Teresa. “That’s why we see double rings, like Vesuvius Cone.”

“Geologically, how reliable is Paricutin for geothermal power generation?” asked Shiyoko, getting to the point of their visit.

“Do you mean, how old is it?” asked Teresa. “Cones generally last decades or centuries; the faster their water flows, the bigger they are and the older they get. Paricutin is average and may have a few decades left.”

“But if Paricutin fills up with ice, another cone will form nearby,” said Marshall. “A thermal field lasts thousands of years.”

“Wouldn’t you drill down and extract the heat from a well anyway?” asked Adel.

Shiyoko nodded. “We’d emplace a deep shaft—hundreds of meters—and pump ammonia down. Compressed ammonia will boil a little below zero centigrade, so it can extract all the heat of fusion from liquid water.”

“How much power can Paricutin thermal field produce?” asked Marshall.

“It can easily make 20 megawatts, which meets half of Acheron Outpost’s demand,” replied Shiyoko. “It’ll take a lot of work to build the geothermal facility and

the forty-kilometer power line. Meanwhile, we can electrolyze water, store the oxygen, haul it back to Acheron, and run it through our fuel cells with local methane.”

“What about wind turbines?” asked Adel.

Shiyoko nodded. “Some of Likoma Facula’s taller cones have pretty good wind on top, and with our dense atmosphere that translates into a lot of electricity. But wind is irregular. There’s almost none at night. When you add in power storage, they’re a more expensive source of power than geothermal.”

“But we don’t need energy storage equipment,” said Teresa. “We can just turn down the reactors when the wind blows.”

“True. There’s no reason for this to wait. We can start on a geothermal well in the next few weeks and the drilling won’t take more than one full-time equivalent.”

“Easy for you to say; the full-time equivalent comes from the exploration crew’s allocation.”

Shiyoko frowned. “Well, the decision’s made. Let’s go look at the drilling site.”

They all turned and, in silence, trudged back down the gap. Teresa led them west along the outer edge of the cone, which was rough with fallen blocks of ice, to a small ridge. “This was here before the cone and has survived a thousand years of eruptions. The gap we walked through fills up and cracks open again and again because of an underlying fault. If we install a hard plastic igloo over the drill and spray water on it to freeze a protective shell on top, it’ll be safe. If it diverts most of Paricutin’s water supply, there won’t be any more eruptions.”

“Where will the water go?” asked Adel.

“We’ll pipe it into the canyon, where it’ll flow away under an ice crust,” explained Shiyoko.

“I hope it’s worth the effort,” said Teresa. “Especially considering we have nukes that are perfectly reliable and can supply us with all the power we need.”

“Yes, but we’re staying and building a commonwealth of our own on Titan. This is a long-term project.”

“We have decided to stay,” agreed Marshall.

Just then there was a beep on the common frequency. “Attention all personnel,” said Yuri. “There has been a roof collapse in N-2. The bubble is holding, but we are evacuating all staff from the bubble immediately. All field personnel: return to the outpost immediately.”

“Amy’s doing horticulture in N-2!” said Marshall.

“Let’s get back,” said Teresa.

They turned and ran to the ranger a half kilometer away. They hurried inside as fast as was safe and Teresa headed for the driver’s seat. She drove as fast as the computer allowed; in low gravity traction was less, so vehicles could go off the road and flip over easily. Meanwhile, Shiyoko and Marshall sat in the back and tapped into the outpost’s computers. He called up Amy’s GPS position. “Thank God, she’s out of N-2!”

“The evacuation status shows that no one is left in N-2,” said Shiyoko. “A ten-tonne block detached from the roof. Get me video from the rib cameras while I check the pressurization of the bubbles.”

“Okay,” said Marshall. “Thank God the bubbles held. In this gravity it weighed a tonne and a half.”

“There are five nested bubbles,” said Shiyoko. She pulled up the sensor data. “The outer bubble was breached,” she announced a moment later. “It must have taken the brunt of the impact. The others are compressed, but holding so far.” She saw Marshall was having trouble accessing the cameras, so she leaned over and clicked on a few icons, then typed in her password. “That’ll do it.”

“Thanks.” Marshall paged through camera menus and found N-2’s rib cameras, which were attached to the metal arches holding up the ice ceiling every ten meters. He flipped through the pictures until he found a good one. “Here, Shiyoko. It’s a series of slabs resting on the bubble’s crest.”

She leaned over and looked at the slabs flattening the top of the bubble. “They’re not touching the ceiling. That’s good; if they were, removing them could cause more debris to fall.”

“We never should have built the outpost underground,” commented Teresa.

“Leave those decisions to engineers, Teresa,” replied Shiyoko. Then she added, “Dry underground tunnels have fewer disadvantages than surface construction. It’s pretty hard to fabricate plastic bubbles that don’t dissolve in a constant rain of liquid methane filled with dozens of dissolved hydrocarbon compounds.”

Shiyoko’s communicator beeped; it was Yuri. “Shiyoko, when will you be here?”

“Forty-eight minutes,” shouted Teresa from the front.

“I’m already monitoring the situation; Marshall’s helping. The slab is clear of the ceiling, so no additional collapse is likely.”

“The slab was under the ice-concrete block we poured on the surface close to the apex,” said Yuri. “More could detach, but the block is intact.”

“We had a lot of trouble with N-2; the surface materials were loose and unconsolidated, and we were not satisfied with the reinforcing efforts. I’ll assemble a team to go in through the access ways from the surface to assess the situation. We’ll probably need to install more rebar from the top, crossbars to close the collapse area, and nets to catch debris.”

“Should we crank up the temperature to melt the fallen debris?” asked Yuri.

“Negative, we don’t want to destabilize any more of the ceiling. We can remove it vertically through the access ways. Give me some time, Yuri. I’ll call the team members right now. They can suit up and collect equipment. As soon as I get there we can go in, start to stabilize the ceiling, then turn to debris removal and permanent stabilization.”

“What will this mean for the other tunnels?”

“Careful reinspection. Sridhar should start on that right away.”

“Got it. Call me if you need anything.” Yuri closed the circuit.

Teresa turned around. “If it’s not one thing, it’s another,” she said sympathetically.

Shiyoko sighed. “I’m afraid so. Whenever we get optimistic about this place, something happens to remind us about the fragility of life here.”

“We’re operating close to the edge,” agreed Marshall.

“Sounds like future tunnels will have to use ‘plan B,’” observed Teresa.

Shiyoko nodded. “Yes, for future tunnels we’ll excavate a shallow depression on the surface and emplace a ceiling of nickel-steel beams and sheets extending ten meters past the tunnel sides, then we’ll melt the tunnel underneath it and pour the water on top to freeze an ice-concrete block over the steel. Much safer. We may need to retrofit some of these tunnels.”

Will sat at his desk and looked out the window at Andalus Square. January 2, 2071: he wondered what the new year would bring. It would be the year of his seventieth birthday; the year supplies arrived from Earth; the year a new wave of immigrants would leave Earth for Mars. He wondered what unexpected events would happen; there were always some.

He sat at his desk and opened the Saturn Commission's website. Ever since the accident a week ago he had followed their progress closely. He was relieved to see that N-2 had been cleared for use and the construction and horticultural work inside had resumed, while repair work on the ice roof continued.

He pulled up his messages. Yevgeny had sent a brief email: *Six more people have decided to return to Earth, raising the total to 307. I feel very sad so many people are abandoning our project to return to terra firma. But I guess I can't blame them; it's been pretty rough here, and some people are worried sick about relatives. The deadline's three more sols, so we'll see a few more.*

Will stared at the screen, saddened. That was three percent of the population of Mars. He typed a reply. *We've done our best, and we should assume they've done their best also. Be kind and understanding. They're welcome to apply to return. Ciao.*

He got up and made himself a cup of tea; it upset him that so many people were leaving. Typically it would be half that number. The galleon *Isidis* was heading to Earth in May on a 210-day trajectory, and would pick up 650 for the return trip.

The next message was a videomail from his sister in Stamford. He held his breath; the early winter had been rough. But when her face appeared on the screen, he could see

she was relaxed. “Hi Will, and happy secular New Year. I hope 2071 sees steady improvement. Heating oil supplies are okay in spite of two bad blizzards. So this will not be a winter from hell! Just as well; we’ve cut down every tree but two on my lot! The news also reported that social security checks will resume this week, and the banks are open, so I should even be able to access money! Thanks again for all your help; I don’t know how we would have survived. I heard from Patrick yesterday and he said he would send me a check next week to start paying you back. Unemployment has eased a bit in the last month, though it’s still bad. Say hi to Ethel, Liz, Mike, and the twins. Bye.”

Will immediately hit reply. “Happy New Year, Molly. What a relief to hear it really is happy! I was afraid I’d hear about another crisis. Take Pat’s check, thank him, and deposit it in the account. I don’t need the money, but we’ll let it accumulate there in case you need it or the Bahá’í community needs it. Our finances have taken a terrible beating; I think Ethel and I are worth a fifth as much as we were two years ago. But Marsian businesses have survived here and people have survived down there as a result. When I write my memoirs, the money will build back up! Please send greetings to all your neighbors and the others I met a few years back. Ciao.”

He sent the message and looked up; Moses Waigwa had stuck his head in the door. “Good sol,” he said. “When can I resume road construction? We’ve got cargo arriving June 1 and June 30, and solar sailers are bringing more every month starting in December.”

“What’s the repair workload look like?”

“As heavy as ever, but it doesn’t have to be. Some of the things we’re repairing now will take a tenth as much time once the spare parts arrive.”

“But if I okay your work, Ramesh will be pressing me to resume galleon construction and June will want to restart work on gaseous core nuclear engines.”

“Then we need a comprehensive plan to shift resources back to old priorities.”

“Exactly. We need a big meeting to review everything.”

“I want to send out one team only; six staff with two road building systems. It’d be a start and that would be good for morale.”

“Wait until May, Moses, assuming the cabinet agrees. What do you think of the latest Chinese proposal for methane and oxygen pipelines connecting the outposts?”

“I just read it last night. Their new robotic system is absolutely amazing, and I’m sure it could be adopted for road construction as well.”

“You mean using nickel-steel paving?”

“Exactly, with the pipes underneath or on both sides to provide additional strength to the roadway. The nickel-iron roadbed to the escarpment has proved to be of high quality and if the Chinese system can be adapted to lay it robotically, we’d produce much more high quality roadbed with fewer personnel.”

“The trick is transporting the thousands of tonnes of paving units; we’d need some huge vehicles. But this is a good time to invest in technology on Earth, and it’d be a good project to do with the Chinese. I’ll talk to the ambassador. And I’ll have Huma call the cabinet meeting next week so we can sort out priorities.”

“Okay. Thanks, Will.”

“Have a good sol.” Will waved as Moses left and turned back to his messages. He had a videomail from Irina Mukhamadova, Head of the Venus Commission. The Venus Commission’s national members had been engaged in delicate negotiations for several

weeks about the project's future. She looked upbeat. "Good sol, Will. I've finally persuaded Germany, France, and Russia to match any Marsian funding spent in their home economies to complete a new batch of surface rovers and Venusian aircraft. We'd like to get them ready for launch to Venus during the upcoming launch window, April through August. But that has triggered a fierce discussion among the Magellan crew. They aerobroke into Martian orbit in three weeks. Twelve are willing to go back to Venus; eight are not. If Magellan stops at Mars for a few months for rest and crew rotation, can you provide the propellant and consumables to fly it back to Venus? Any possibility eight Marsians would like to join the mission? Bye."

Will pulled up the Magellan's flight plan and ran Astrolabe, their trajectory plotting program. "Irina, I see the launch window from here to Venus opens in May and would get Magellan back to Venus in late November, about the same time any terrestrial cargo would arrive. The Magellan crew should aerobroke into Martian orbit and go to Phobos for shore leave, then leave for Venus in early June after our first cargo flight has arrived. We have ample basic consumables and Phobos's propellant tanks are full. We may be able to recruit replacements for the eight who want to stay on Mars and five months is plenty of time for basic crew training. They'd be welcome to visit."

Will was surprised to hear from Jacquie Collins. The Mayor of Tithonium wasn't in Aurorae very often, but the Mars Council had been meeting for several sols, and she was the Council's Clerk, its second-ranking officer. He was even more puzzled by the group she was bringing to his house for a meeting late Monsol evening: Ramesh Prathan, Moses Waigwa, and June Addison. He and Ethel had coffee, tea, and some little cookies ready.

“Ramesh approached me at the Council meeting asking about the latest data on PGM and gold production and sales,” Jacquie said. “Because he was curious about terrestrial resources that could be available for development of some new equipment.”

“And Moses is interested in the robotic pipeline-laying system the Chinese have developed,” added Ramesh. “June wants to get gas-core production started.”

“So we thought we’d propose a plan to reallocate resources here and on Earth,” concluded Jacquie.

“Do you have the latest projections?” asked Ethel. “PGM demand is definitely on the rise and it should continue to grow, so Parenago will reopen and Uzboi will expand back to its prewar population.”

“We heard,” said Jacquie. “The price of gold has already started to fall, but PGM prices seem pretty good.”

“Yes, we think PGM prices will be fairly stable,” agreed Ethel.

“So, what are you proposing?” asked Will.

“We gather that immigration will be 1,000 in 2072 and perhaps 2,000 in 2074, and we’ll need possibly one more galleon by then,” said Jacquie. “So Ramesh wants to produce one galleon over the next two years, and June would produce one gaseous core engine as well. Those are minimum levels for keeping the teams active, but demand won’t call for anything more.”

“I think that’s a reasonable assumption,” agreed Will. “The Saturn Commission wants a galleon to fly to Titan with replacement crew in 2072. I’m hoping we can talk the Jupiter and Asteroid Commissions into buying two galleons each over the next six years.

After that, we'll see when a mission to Uranus or Neptune can be planned; probably not before 2080."

"That's optimistic, too," said Ramesh. "Our own need for galleons won't grow by more than one per columbiad. But I have an ambitious plan for expanding the area of polder available for agriculture. Lisa Kok wants to increase our pressurized area to at least 120 square meters per person, preferably 150. That will allow us to raise a wider variety of plants for industrial purposes and will reduce the machinery needed per person. Based on that, Aurorae needs at least one new 300 by 700 meter enclosure."

Will was startled by that. "Three by seven? Ukraine's three hundred by five hundred. I thought Lisa didn't want low pressure enclosures and you favored B-75s."

"Yes, three hundred by seven hundred; bigger than Ukraine," confirmed Ramesh. "And no, *not* low pressure, and not B-75s. I still like B-75s and favor them for interdomal underground construction, but we need large open spaces, too. Our engineering team has developed new robotic pile driver and regolith sifters. For less than a hundred million redbacks, we can contract a terrestrial firm to convert our plans into reality, and now that we have cargo transport restored, we can import the essential parts or entire pile drivers from Earth in less than two years. The new robotically controlled regolith-moving equipment will reduce the cost of site preparation; our equipment already has the computing power and now we can install new software. The new enclosure, which we're calling 'Caribbean,' can be completed for half the cost per square meter as even Ukraine."

"How are you going to hold in standard atmosphere with sides three hundred meters apart?" asked Ethel, surprised.

“With a central line of pylons,” replied Ramesh. “Each pylon will receive a cable from directly overhead, one from the middle of the right half of the dome, and one from the middle of the left hand of the dome. We could even retrofit Ukraine for a standard atmosphere, with a system like that. And it’s expandable; two lines of pylons could hold down a dome 450 to 600 meters wide, for example. The era of truly enormous pressurized spaces is about to dawn.” He said it with a definitive tone.

“What about the other boroughs?” asked Will.

“They’ll get one, too. Aram really wants enclosures this size.”

“We can certainly produce the nickel-steel pylons cheaply enough,” said Ethel.

“The new truck-trains will make it cheap to move stuff between outposts, too,” added Ramesh. “We can already string twelve self-steering and self-braking trailers behind two engine units, but new software will allow that to increase to fifty, so we can haul pylons, metal housing modules, pipes, and other goods anywhere at a reasonable price. Moses wants to resume work on the highway system. If we can upgrade to Chinese robotic systems, we can build them fairly cheaply, too. But we’ll need to spend a half billion redbacks on research and development in China to get the system we want.”

“That’s the trick,” agreed Will. “It’s cheap here because we have to spend a lot of money on Earth.”

“But right now, we can spend a lot on Earth,” said Jacquie. “Because of the economic situation, labor is relatively cheap, and we have a lot of assets.”

“Put in a proposal,” said Will. “Because we’re looking at this issue right now. We should have cash left over after investing in the new Prometheus shuttle and in the new Swift shuttle factory. If we can restore significant launch capacity—not just a thousand

tonnes a year, which is pretty small for us—we'll be in the position to launch new robotic trucks and trailers, pipeline systems, robotic factories, all sorts of things. But timing is crucial because the price of gold may decline sharply in the next year and PGM production probably can't make up for it. Launch prices to Earth orbit are pretty high right now, too. Our assets won't last and they can't be stretched to accomplish everything we need."

"Now that we've imported a lot of people, though, we need to import a lot of machines and robotic systems, don't you think?" asked Jacquie. "Because we have the capacity to use them."

Will nodded, pleased with her insight. "I think that's true if we can increase launch capacity. We need two thousand tonnes per year; four thousand per columbiad. We'll be competing with orbital factory investment, too, if things keep going well, which means we also need to consider ways we can expand Phobos, because right now we can capture a lot of new markets. There are a lot of possibilities right now."

2.

Resupply

June 2071

A cargo capsule streaked into the Martian atmosphere at ten kilometers per second, burned off its excess speed, then shot out of the atmosphere four minutes later glowing red hot. Will Elliott sat in Mars Control with one eye on Rostam Khan and the other controllers as they monitored the data. The other eye stayed focused on a television screen and the long range camera image of the capsule.

“Aerobraking complete,” Rostam calmly announced as the capsule exited the Martian atmosphere. “The delta-v is perfect. Forty tonnes of cargo is now in Martian orbit.”

“Congratulations,” said Will. “You guys are good. When will the shuttles rendezvous?”

“They’ll need forty hours. The capsule will fire its engine in twelve hours to raise its periapsis out of the lower atmosphere. The next atmospheric pass, through the upper atmosphere, will lower its apoapsis to the orbit of Phobos. The second firing will raise the periapsis to 200 kilometers, which will give the shuttles plenty of time to finish their rendezvous. We’ll have spare parts, vaccines, and Coca-Cola extract on June 2d.”

Several crew laughed at that; Will had to smile as well. “As soon as the *Kasei* touches down with the cargo, I’ll declare the end of the state of emergency and a holiday,” he said. “Watch everything like a hawk; we don’t have our cargo yet, and we

don't want to lose it now. Let me know if there are any anomalies." Will headed out of Mars Control and back to the Commonwealth Building.

He had to cross Andalus Square and it was in a festive mood; the aerobraking had been broadcast live on big screens in the Gallerie and on the square. Several people congratulated him. Back in his office, he saw that messages were already pouring in. "The Commander of the *Magellan* just called to thank you for everything," said Huma.

"Oh? Let's call him back. Anisa, Commander Levere, please." Will sat at his desk and waited for the call to go through to the caravel formerly in Venus orbit but now landed on Phobos.

"Chief Minister Will, thanks for calling me back. I had just wanted to congratulate you on a successful aerobraking."

"Thank you. The shuttle *Shalbatana* will bring two tonnes of supplies to Phobos in three sols, and one tonne is destined for you."

"They'll be of immense help. As you know, we're scheduled to leave for Venus on June 7. Our stay at Phobos is almost over and we're immensely grateful for your hospitality."

"We were delighted! You all took Martech by storm. We never would have gotten a dozen courses on Venusian atmospheric physics, mineralogy, plate tectonics, volcanism, atmospheric evolution, and crustal chemistry. And they were popular! You're returning to Venus with just about a full complement."

"Only two short, which is fine. We're very grateful for everything, Mr. Chief Minister."

“We are glad to help. You should have new equipment for the Venus surface and atmosphere shortly after your return to Venus orbit, too, so you should be back in business. I hope the Venus Commission agrees to expand your presence with a galleon.”

“Perhaps in a few years, when the situation on Earth returns to normal. But Venus is in your debt; I dare say, we are now in Mars’s sphere of influence!”

“We hope all the solar system will turn to us for equipment, resources, and personnel. My best wishes to you again, Commander Lavere. Good bye.”

“Bye.” The line closed. Will looked at the screen for a moment, contemplating the six months of cargo that the United States had launched for Mars. It was time to give the Chinese a turn. “Anisa, please connect me to Ambassador Tao.”

“Acknowledged,” replied the voice of his tablet. A moment later the communicator at the other end began to ring.

“Mr. Chief Minister, congratulations on the aerobraking,” said Zhao Tao a moment later, as his face flashed onto the screen. “Our relief will be complete in about forty-eight hours when the cargo is landed.”

“Exactly, Mr. Ambassador. We’ve launched 520 tonnes from Earth, and it’ll all have landed, nine months from now. I wanted to ask you about cargo for launch in the next four to six months. Our engineering team has been looking over the latest proposal for an automated pipeline-laying system. Shenzhou Limited has a very impressive product, and our engineers have ideas for adapting it to the cold here, as well as utilizing nickel-steel or nickel-iron that can be produced cheaply at Uzboi.”

“Excellent.”

“They also think the system can be modified for laying and welding nickel-steel paving panels. Uzboi has a mold for making half-centimeter nickel-steel plates twenty-five meters long and ten wide, massing about eight tonnes; they’re welded together robotically to make metal boxes for housing and offices. They can modify it to make a mold for nickel-steel paving panels of the same size and mass with pipes built into the bottom. The panels over the pipes won’t be metal plate but a heavy grate with a thin metal top and long hollow metal ‘feet’ that are pressed into the substrate to hold the unit in place, then steam and water are injected through the hollow feet to freeze the substrate.”

“With a right-hand tire furrow, just like the Escarpment Highway?”

“Exactly; it’s a very reliable, safe, fast driving surface, and if the system is designed right, it can be upgraded to accommodate hyperloop. Shenzhou has sent us a proposal for an automated system for road grading, panel placement, and welding. Our engineering team has also been looking at self-driving trailers produced in Beijing. We are interested in a contract with Shenzhou to modify their systems for us; we understand from them the modification and production of four units could cost a half billion redbacks. But we need a separate Chinese launch contract because the Americans won’t launch Chinese equipment for us.”

“Of course, and I’m sure we can give you such a contract, as our shuttles are now able to undergo repairs. But launch costs are high currently.”

“We can pay you a thousand redbacks per kilo for six months, and then we’ll have to look at it again, or if you prefer we can make a long-term contract for so much cash up

front and so many tonnes over the next year. If you could launch a thousand tonnes for us over the next year, we could use it.”

“What about your contract with the United States?”

“The exclusivity clause expires next week. I can’t renew it if China is launching something essential for us, can I?”

“No, you can’t.” Tao smiled. “Shenzhou Limited has kept me informed of the discussions, and I am delighted they may bear fruit. Do you want my assistance to finalize the contract?”

“Possibly, but Ruhullah can go to their headquarters to finalize the wording. When you first proposed a pipeline connecting outposts, it looked too expensive for us. But the new robotic systems make it much more practical, especially if the pipeline is laid with road paving panels. Our revenue surplus on Earth wasn’t in place when you first presented the idea, either. We’re looking at big infrastructure investments in the next two years while the revenue can yield maximum benefits.”

“That makes sense. So: A half billion redbacks for the pipeline and road laying system and a billion redbacks for launching a thousand tonnes of cargo.”

“I said six months, not a year, so 500 million, assuming you can get 500 tonnes into orbit for us. But it could become a billion. We’re bringing a thousand people here, this coming opposition, and up to 200 of them could be Chinese. The Americans have already launched 250 personnel for us and they’re running Peary and Parenago. The majority is Americans; the State Department dropped its travel restriction. China would have to do the same.”

“I’ll inquire about that. I think the restriction can be dropped, especially if you pay a premium for their launch into orbit. If we can finalize the launch contract and include personnel, the travel restriction would have to be dropped.”

“Exactly. We’re looking at 500 redbacks per kilo in our next launch contract with the Americans. The Europeans are now launching once a month to Ibis Hotel and their contract with the Venus Commission charges it 389 redbacks per kilo. So competition is growing. The Australian, Japanese, and Brazilian shuttles should be working within a month or two. I could see a contract with China for the second six-month period for 500 redbacks per kilo and 1 million per person, though. That’s generous, but we’re grateful to China for its support in the war.”

“I think it helps make up for the situation with our reactors, too. I’ll take your offer to the government and get back to you as soon as possible.”

“Thank you.”

“There is one matter I want to ask you about, Chief Minister Will; one I’ve been meaning to call you about: the launch of the caravel *Sagittarius* to Jupiter next week. We’re disappointed that there aren’t more Chinese crew on board.”

“I don’t know much about that, Dr. Ambassador. I gather the crew is small—twenty five rather than the full complement of fifty—and that we advertised the positions widely, but not many were willing to make a four year commitment to the Jupiter Commission. Callisto lacks intersatellite capacity, which means no manned missions off the surface. Cargo will be on its way from Earth in two months and everything arrives in a bit over a year. It’ll be a huge boost; morale’s pretty low there right now.”

“I know that, but intersatellite capacity is not badly needed anyway; the radiation environment precludes manned missions to Io, Europa, and generally to Ganymede, the inner moons have already been visited, and the outer moons are a motley collection of captured asteroids. China is planning to send a caravel and additional cargo in 12 to 24 months. We feel upstaged by your efforts.”

“I see, and I apologize about that. We had no desire to embarrass China. But we are in a very different position than you. China has just restored launch capacity; we have always had it. China is recovering from vast damage and loss of life; we are not. We felt we were in a unique position to assist.”

“I’ll convey that explanation to my government. Our biggest concern right now is restoring our launch capacity and our contract with you should help immensely, as will the contract with Shenzhou Limited. Thank you, Mr. Chief Minister.

“Thank you to you as well. Have a good sol.”

“You, too. Goodbye.”

“Goodbye.” Will closed the circuit, pleased with the negotiation, though the complaint about their support for Jupiter surprised him. He had already talked to his cabinet about several moves, and a launch contract with China was one of them. They hadn’t yet finalized a contract with the Americans for the next six months, but now 500 redbacks per kilo was more likely, especially with Theodoulos, Ruhullah, and Shtockman negotiating with the various other shuttle operators, all of whom wanted high-volume, long-term contracts so that they could recover. Ironically, Mars might import more in 2071-72 than it ever had before.

The image of the graduation ceremony for Aurorae High School was large, clear, and three dimensional on the screen of Central Station, Ceres. Twenty young men and women were completing their high school degree that sol, and after each name was called out, the crowd applauded. When the name “Charles Langlais” was announced the applause came from fifty adults and children gathered in the great room in Central Station as well as in Andalus Square. Charlie stood up and walked forward to Julie Lafontaine, who was in charge of the education of the community’s children. She proudly handed him his diploma while the principal of Aurorae High explained to the crowd that Charles was receiving his diploma that very minute on Ceres.

Once the last diplomas were passed out, the graduates on Mars threw their hats into the air and Charlie did the same, though it just bounced off the ceiling and came back down immediately. Helmut rose. “Congratulations, son.” He hugged his nearly eighteen year old son proudly, followed by Clara and then the entire community.

“Speech! Speech!” said Adam Haddad.

“Speech?” asked Charles, smiling. “Well, I want to thank everyone for encouraging me, answering my homework questions, advising me about paper topics, helping me organize my work, and generally mentoring me through all these years of school. I’m really looking forward to being a regular member of the crew from now on, even though my eighteenth birthday is still five months away.”

“When do you start college?”

“I’ll be taking Martech courses starting next month. Of course, they’ll be online only. I’m planning to return to Mars on the *Wolf* with the crew of the Trojan mission next year.”

That surprised several people, including Helmut, who had thought he had talked Charlie out of it. “We really could use you here, though, Charlie.”

“I know, dad, but I want to go to university, I want to have classmates I can actually meet in class. And, well, especially the girls.”

“Of course!” said Adam right away.

“We are a pretty small, isolated place,” admitted Clara.

“How many people are leaving next year, anyway?” asked Adam.

Helmut took a small breath. “Right now, eight; the maximum number they can accommodate. Two from the Trojan mission plan to join us, though, so we’ll be down by six. The Asteroid Commission was unable to send us a caravel last year, as you know, but they are committed to a launch in 2073 with a crew of 25. At that point, a large number of us can head back to Mars if we are so inclined, or we can see this place grow even larger. I’m hoping we can get upgraded to a galleon later in the decade.”

“But does Ceres warrant such a large crew?” asked Juliette. “We’ve already explored its entire surface and we can’t drill much farther inside.”

“Perhaps a ten-year mission to Vesta or Pallas is warranted instead,” added Jack Alberghini. “Ceres doesn’t have to be permanently inhabited at this point in its development. Maybe in the future it should be, though.”

“Perhaps you’re right,” said Helmut, though he loved Ceres and didn’t want to contemplate its abandonment. “The entire belt needs to be studied, and that means thousands of worlds, and many of them will require a human presence. If we had three vehicles here, we could send out expeditions to passing asteroids; a lot more come close to us than come close to Mars or the Earth.”

“Or perhaps Mars should send out one-caravel missions like our first one,” said Clara. “There are a lot of ways to explore the Belt. We aren’t exploring the Belt; we’re just exploring its largest body.”

“Let’s remember that Ceres isn’t an asteroid as much as it is a dwarf planet,” replied Helmut. “This is a big world; it has a third of the total mass of the Belt. It has all the water and other elements one needs to live, a decent level of sunlight, and we’ve found some pretty good PGMs, the market for which is recovering. We’ve done well here.”

“That’s certainly true, Helmut,” agreed Juliette. “But even so, there’s no guarantee this place is now permanently settled.”

“Some of us are getting tired of being here,” added Adam. “Remember, our nominal mission was two synodic periods; 6 1/3 years. That was up last year. In 2073, we’ll have been here nine and a half years, which is more than most of us wanted to stay.”

“I know,” said Helmut. “It sounds like we’ll need to start a lengthy discussion about the future of this place and who plans to stay after 2073.”

The Aurorae High School graduation was followed the next sol by the landing of the *Nirgal* with thirty-eight tonnes of supplies. Will Elliott declared a national holiday and the end of the emergency. Everyone celebrated; sales in the stores shot up. Will and Ethel went to Uzboi for two sols to rest in their condo there and talk to the mayor about restoring the outpost’s old population and its PGM production. When he returned, he invited the Ambassador of the Grand Union to his office.

“So, as an economist, where do you see things headed on Earth over the next few years?” has asked Mariella Fsadni, after making her a cup of coffee.

She smiled. “I don’t have a crystal ball! But everything I see agrees with the economic projections. Europe, India, Australia, and parts of Latin America are recovering well. The United States and China have a long way to go because of all the damage to their infrastructure; they’ll need loan guarantees from the Grand Union in order to borrow from its banks and repair the damage.”

“But those loans seem pretty likely now.”

“Yes, China has come around to an autonomy arrangement with Tibet and Shinjang, and the Americans have found Knight, MacKay, and Vanstone guilty. Whether those nations will be able to keep their agreements remains to be seen, but right now the negotiations are moving forward well.”

“That’s why I wanted to talk to you. Perhaps it’s time for the Grand Union itself to cement its unity with a grand space project.”

Fsadni looked at him surprised. “Uranus? Are you out of your mind?”

“Not at all. Very little new technology is needed. It’s simpler than the Titan-Saturn mission. A Uranus mission needs the cryogenic moon technology developed for Jupiter and gas-core propulsion systems. It’s a matter of purchasing the equipment: four galleons, two caravels, four gas-core engines, four 15-megawatt nuclear reactors, a dozen B-75s, a dozen surface vehicles, several dozen satellites and probes, etc. Mars can assemble most of the equipment and the Grand Union nations can provide most of the parts. Spread out over nine years—I’m talking about a 2080 launch—the annual budget is actually quite small.”

“Perhaps, but I heard from Érico yesterday and he was asking the Grand Union to help the Saturn Commission; they want two more galleons as well. The Jupiter Commission wants galleons as well, and they badly need the upgrade. Don’t you think Jupiter needs the priority? How many of these missions can we support?”

“How many can Earth and Mars support, working together? How about seven? Mercury, Venus, Ceres, Jupiter, Saturn, Uranus, and Neptune? We have five of them now and if we add one per decade, we’ll have a foothold on the last two in two decades.”

“Do we even want to ‘settle’ these places, Will? Really; think about it. These are distance places, impossible for us to support meaningfully, and very hostile environments. Look at the terrible difficulties the Titan settlement has had. Do Marshall and Amy want to stay permanently? Even Ceres is now having its doubts; I read this morning in *Mars This Sol* they’re starting a whole new debate about the long-term viability of their project.”

“I read that too, and asked Helmut about it. Mariella, we can get the propulsion technology right, we can get the surface technology right, we can get the habs and ecological management right, but we still haven’t figured out how to get the social and cultural dimension right. Mars worked because it kept growing; it was exciting, people were willing to stay because it was progressing, and by the time the kids grew up, there was a community of children as well. Ceres is facing its time of reflection because Charlie Langlais said he felt he needed to leave, partly because there are no girls around! These are career scientists and explorers, not career settlers. Look at Mercury; people spend a few years there, leave for Earth, return for a few years, go to Mars for a few years, etc. Venus, too. A lot of the Marsians on their way back to Earth right now plan to

work on the moon and some may be back here. Érico and I were talking about this the other day and we think the key is regular exchange of personnel. If a crew made a ten year commitment and we provided a round trip flight of two to four years—depending on the destination—we could keep two galleons at each location and keep two flying back and forth. That’s why I think a Uranus commitment needs four galleons and four gas core engines. So will Jupiter and Saturn. Ceres can possibly manage with two more caravels, or two galleons for the surface and two caravels for crew rotation.”

“Of course, we thought caravels were big enough, and now everyone wants galleons! When Mars develops a “supergalleon” or whatever, won’t they want those instead?”

Will shrugged. “Perhaps they will. But we have no plans to develop a larger vehicle for at least five years. With gaseous core engines, a galleon can dash here in three months or less and make two round trips per columbiad, and during the fast dash it can carry up to 750 people. Neither the terrestrial nor the Martian transportation systems between the surface and orbit can easily handle that many people. If a ‘supergalleon’ that can transport 1,200 is developed, could we use it? Does exploration of the outer solar system warrant such a vehicle? Right now, the answer in both cases is no. A pair of galleons, providing each other life support and propulsion redundancy and added radiation shielding, can transport 300 people to the outer planets. With subsurface accommodations for low gravity offices and agriculture, either galleon can house 300 on the surface of an outer-planet moon, so two could support a settlement of up to 600; or as few as 150, for that matter. A settlement of 300 to 600 provides much of the social and

cultural variety that a successful community needs; certainly it is sufficient for a six to ten year stay.”

“Interesting concept,” said Mariella. “So, that’s why Érico asked for support for purchase of two galleons for Saturn.”

“Exactly; I told him I’d let him talk to you first! Saturn needs the support more; theirs really is the hardship assignment of the entire solar system. Jupiter needs galleons badly, too. One galleon could replace both of the caravels on Callisto and bring the two crews together under one unified command. Two galleons would double their capacity, and they have far more worlds, and complex worlds, to explore than anyone else. But we’re talking about a decade, Mariella. Four galleons for Jupiter, four for Uranus, and two more for Saturn: that requires completion of only one per year and a commitment of only 1.5 billion redbacks per year, and Mars will cover half that. Including the gas core engines and reactors, the Grand Union will still be committing only a billion redbacks per year. It’s not huge. No doubt, many member states will make individual commitments and reduce the joint commitment further.”

“And what will Mars commit, and why?” Mariella looked at him intensely.

“Right now, with our PGM and gold production, we can afford to commit our construction teams and the construction materials we make here. That’s about 1,200 people of our 8,000-person workforce. They will also be making a few galleons for us, because we want to expand our fleet to increase immigration. If they just made one galleon for Mars every two or three years, we’d still need to commit half that number, so it is cheaper for us to use our system at full capacity. We can’t make computers, gyroscopes, and advanced equipment of all sorts. We’ll buy them from you. Why are we

committing almost a sixth of our work force? Because on Earth, far more than a sixth of government budgets are committed to military and retirement, and we have no military commitments and very small retirement commitments. Naturally, we are committed to exploration. Where will the crew for these worlds come from, and where will they return to? Mars.”

“As you said, Mars will lead humanity to the stars.”

Will nodded. “I think we will. It’ll be a century; we don’t know how to get people there right now, if they travel fast we don’t know how to shield them or slow them down at the other end, and if you think 300 people is a big commitment, an interstellar community will probably be much bigger!”

“You certainly have vision, Will. Alright, I’ll talk to people in the European Space Agency and in the Grand Union secretariat; as you know, they don’t have a space agency or even a space committee! Your request may have to be bumped downward to lower levels. I think you need to write up and speak about this new vision for solar system exploration. It’ll take some time for it to be considered seriously.”

“Mariella, when have I not spoken and written about a major project! You can be sure of it. Our emergency is officially over and the remaining problems are now much easier to manage because we can postpone most of them until supplies arrive. I have two years left to this term as Chief Minister and I want to be sure to use the time to restore and refocus our vision. Because that’s what keeps Mars moving forward.”

“These new counter-pressure suits are really comfortable,” said Mike, as he and Will approached “Crater Lake,” their crater where all waste water went.

“I’m impressed,” agreed Will. “It feels like a scuba suit and is pretty flexible.”

“Even the groin area is pretty well designed. How many did we import?”

“Just four! We didn’t have much mass to spare on the first two cargo shipments. These are getting constant use.”

“They’re booked a week in advance. Are you importing a lot of them?”

Will nodded. “A thousand! And I suspect the solar sailers will carry even more, next year.” He pointed to a nearby airlock that would take them into the “Crater Lake” enclosure. Mike nodded and pointed to a rise nearby where they could see the construction better. They walked over to the rise and climbed to the top, where they could see two pressure-suited figures carefully walking across the crater’s plastic bubble, pulling cables with them.

“How much pressure are they going for?” asked Mike.

“By the end of the summer when the pile drivers are finished and the cables are properly anchored, a tenth of an atmosphere. Right now the pressure inside is a third of that. As you can see, they’ve installed a Kevlar net over the plastic bubble, which means they can install additional cables. They should be able to rate it for 0.33 atmospheres in a few years, if we decide to go for standard pressure.”

“The crater’s pretty wide for that, but I guess the technology has gotten better.”

Will pointed to the airlock entrance and they walked over and entered. The transition to the inside was quite quick; in less than a minute they opened the airlock’s inner door and entered a tunnel leading to the crater. The lights came on as they walked down it to the sunlight end.

“Wow!” said Mike when they reached the terrace overlooking Crater Lake. The entire floor of the 300-meter crater was flooded to a depth of twenty meters; a plastic depth scale installed on the far side barely showed “21” above the ice and water. A stream of water cascaded into the crater to the left.

“How much per day?” asked Mike, looking at the stream.

“Two thousand, five hundred tonnes per day. It sounds like a lot, but that’s a small creek on Earth. New Hanford recovers almost half a tonne of deuterium from it, so the water is free. In ten years, this crater will be full and we’ll probably let a bunch of it spill out, so we can simulate a small catastrophic flood on Mars. We can’t use it fast enough.”

“Is it freezing or thawing? I can’t tell. There’s an ice layer over the entire crater and a foot or so of water on top of the ice.”

“It’s shifting into a thaw situation. At first, the water poured out of the pipe and froze solid, but with the plastic trapping the solar heat, the crater has been steadily heating up. A few months ago a meter of water accumulated on top and the entire ice block broke free of the crater floor and floated to the top. But it froze back into place and water’s accumulating on top again; meanwhile, the liquid underneath is freezing. Someone has calculated that in another year or two, solar heating will tip the balance and the ice block will gradually thaw over a three year period. If we heat the effluent from New Hanford or add some carbon black, we can accelerate the process, and we might do that.”

“So in a decade I might be able to come in here and sail a sailboat on it?”

Will chuckled. “You can do that on Baltic Lake right now! But yes, by then it’ll be a standard atmosphere in here, the lake will be stocked, and the crater walls will have pine trees and other vegetation. It should be pretty.”

“Sounds a bit like Frenchman’s Bay in Maine, where I grew up,” said Mike. “I’m looking forward to it. And by the way, I need to take you sailing on Baltic Lake some time, though it’s smaller than this.”

“Yes, I’d like to try that.” They looked at the lake one last time, then headed back to the airlock so they could walk back to the Outpost. It was a quick 1-kilometer, 10 minute hike; they had wanted to try out the new counter-pressure suits.

“So, Shayda has started walking, but not Jason,” said Will.

“Yes, on their birthday. Jason’s trying, though; give him a few more sols and he’ll be upright, too. He’s already crawling around and trying to open everything!”

“Yes, I remember that phase. I’m glad you have everything child-proofed.”

“I’m glad the stores have child-proofing stuff again! But we mostly moved everything up to higher shelves.”

“Do you have your paper written?”

“Almost; I got two hours done last night after the kids went to sleep. When are you going to get back to writing papers?”

Will smiled. “It’ll be a few years, I think. But I have been writing.”

“Yes, I read your op-ed about the new solar system exploration plan in yestersol’s *Wall Street Journal*. Has there been any response?”

“Pete says several Senators and Congressmen sent him emails via their aides, usually positive, though one said I shouldn’t interfere in American policy.”

“But the op-ed called for the Grand Union to support these missions, not the U.S.!”

“I guess that’s interfering in American policy. The fellow certainly wouldn’t have thought of saying I shouldn’t interfere in Grand Union space policy because I’m not a resident of Earth!”

They chuckled at that. “No, I suppose he was an America-firster.”

“Definitely. Senator White.”

Mike laughed at that.

“But we’re beginning to move some people. Mars is solidly behind it, of course; it’s to our advantage. I’m not sure the Grand Union will get its act together and create a space policy. But plan B is to approach the U.S., China, the European Union, and the Latin Union. France is solidly behind Mercury and the European Union has reaffirmed its commitment to Venus. Mars will have to commit to the Asteroid Commission, and since that’s our back yard, we should. The U.S. and China plan to continue their Jupiter support. It’s looking like a consortium of Canada, Britain, Australia, Japan, India, some smaller countries, and Mars will continue Saturn. I suspect we have Brazil behind the Uranus project, and that means the Latin Union.”

“So, that’s everything but Neptune!”

“Which is still a long time away; 2085 to 2090. But Ruhullah is working on the African Union, believe it or not! I think they will give it a try.”

“Fantastic.”

They had reached the Cochabamba airlocks. One was occupied, but another one had a green light on top, so they approached it and commanded it to open. They entered

and a powerful blast of carbon dioxide enveloped them for several seconds to blow off most of the dust on their suits. The outer door closed and air pressure began to build around them. Their counter-pressure suits automatically began to relax. When the inner door opened, the suits were actually loose. They walked into the men's locker room, peeled them off, and dressed. Mike headed for the university on foot and Will took an autobus to Andalus.

When he reached his office, Érico was waiting. "Have you got three minutes? I saw you were on your way here and I was getting coffee in the Gallerie, so I thought I'd stop by to update you about Saturn."

"Sure, but Alexandra should be here in five, so three is about all I have."

"Three is plenty. Yevgeny, Emily, and I have been engaged in talks over the galleon that is nearly finished at Phobos. It can be completed by the middle of next year when a launch window opens to Saturn. We'll name it the *Cassini*, naturally. We want to send 100-200 personnel to Saturn on a two-year trajectory; we're asking for an eight-year commitment, four in transit and four on Titan. We plan to start recruiting immediately."

"Just one galleon? That doesn't provide very good radiation shielding for families."

"We're hoping to minimize the number of children anyway, but one possibility we're considering is using the gaseous core engine for launch only, and hauling along chemical propellant for Saturn orbit injection. Five hundred tonnes of hydrogen and oxygen will provide excellent shielding; about a third of a tonne per square meter, including the mass of the galleon itself. Until the Saturn Commission can get two

galleons, we'll send one back and forth, heavily shielded with tanks of propellant. It'll also be accompanied by a caravel."

"You should have two by 2073."

"Quite possibly. We may alternate launches between the Earth and Mars and send a vehicle every three years. A launch from Mars every other opposition—every fifty months—may be sufficient as well. We'll have to see what works. The Jupiter Commission is also looking at personnel rotation every 3 or 4 years."

"It would save a lot of money, as would the use of a single heavily shielded galleon. Thanks for letting me know. I presume you need priority accommodation of any crew coming from Earth?"

"Absolutely."

"Okay, I'll send a memo to Immigration. Anisa, please make it so. Oh, here's Alexandra, right on time. Thanks for stopping by."

"Sure. Have a good sol, Will."

"You too, Érico. Ciao." He waved and Érico headed out of the office as Alexandra came in. "Good morning! Shall I make your usual?"

"Sure, Will. Anything new?"

"Mike and I just tried out the new counter-pressure suits on a hike to Crater Lake and back. They're really comfortable."

"People are raving about them. We're still dependent on very clever engineers on Earth, I'm afraid."

“Interdependent, I’d prefer to think.” Mike handed Alexandra a cup of tea. He poured a cup for himself and they sat at his table. “So, the Prometheus is coming along well, I understand.”

“Yes, impressively so. The shuttle design was quite good; Russia still has some of the best rocket engineers you’ll find. And as usual, their plans were stymied by lack of funding, which we were able to resolve. Its engines are the best ever designed; they’re methane-oxygen for the first stage and hydrogen-oxygen for the second, with a higher specific impulse and thrust to weight ratio than ever achieved. The first stage is good here and on Earth; the second stage is good for the moon and outer planets where hydrogen is the preferred fuel. The two engine types are laser-sintered three-d printed, so they’re cheap. The new heat shields are the lightest ever made and the avionics are completely new, using the latest artificial intelligence. Prometheus is self-flying; no pilots. The stages are made of metal-reinforced composites, which are thirty-three percent lighter than metal alloys, and are fully reusable, probably forty times each before a major overhaul is necessary. Routine launch turnaround is 12 hours nominal. Manufacturing costs are 50 million redbacks per Prometheus because of automation. The payload can be sixty tonnes of cargo, fifty-five tonnes of liquid hydrogen, or one hundred fifty people. Launch costs should be about six million redbacks each, or 100 redbacks per kilo for cargo. For people, one has to add the cost of the cabin, but it is still 50,000 redbacks per person.”

“Wow, that *is* a revolution. That’s cheaper than launch from here to Mars orbit!”

“And both stages are designed to serve as a single stage to orbit vehicle for us. That’s the beauty of this design; the stages are designed to land vertically, just like the old Thunderbirds, rather than horizontally, like the Swift shuttle. The latter design was great

for Earth, but impossible for Mars, and because it worked well it was improved steadily, leaving our system behind. Now the vertical take off and landing system is advancing technologically and it will benefit Mars as well. We'll be able to launch for thirty to fifty redbacks per kilogram. We'll be able to send gold and PGMs to Earth using the new shuttle and solar sailers for forty to sixty redbacks per kilo and we can get people here for half a million redbacks each."

"So, the large immigration can continue, if we have the will."

"Exactly. We're keeping it to 1,000 this opposition, right?"

"That's my pledge, but that's 1,000 net growth; we have 300 going back, so that means 1,300. And I think we can plan for a bigger than average immigration in 2073, maybe 3,000. When will the Prometheus launch?"

"That's the other good news. The original three-year timeline is accelerated because we lavished so much gold on the project. It'll be available by next January, in time to send some cargo to Mars. It'll certainly be operating by mid 2072 and available for a big immigration in 2073. We haven't begun to consider the impact the Prometheus will have on lunar development and tourism, low earth orbit industrialization, and the vision for solar system exploration you have laid out."

"But it'll be positive."

"Oh, yes. Very positive."

3.

Changing Priorities

August 2071

Kristoff stared at Ramesh, more puzzled than angry. Lisa Kok looked at the two of them and wondered what had happened between them in the past that had caused the tension.

“Let’s get this meeting started,” she suggested. “I think the sooner we resolve this issue, the better for all our schedules.”

“It’s pretty simple,” said Ramesh. “Upgrading Ukraine to standard atmosphere will make its use much easier, raises the value of the land, and permits recreational use. I’ll need to sink five pylon complexes—each has four nickel-steel ‘stakes’ fifty meters long—in a line along the middle of the enclosure. Each stake will have three or four cables running from it to spots along the dome apex. Each pylon complex will take up a ten by ten meter spot, so we’ll use up only 700 square meters of the 21,000 inside, or four percent of the polder. Installation will require a larger footprint and a temporary access road for a month per pylon, but we’ll compensate you for lost crops.”

“My question is very simple: why?” asked Kristoff. “Because I don’t want Ukraine converted to standard atmosphere. It’s zoned farmland and if we want more residential space, we can enclose more land; not only will it be cheaper than upgrading an existing structure, but we won’t have to move topsoil. If the polder can’t be converted to residential, its value won’t increase. And I don’t want ‘recreational use,’ which basically means people will be walking around my farm.”

“But surely the current situation is highly inconvenient for you?” persisted Ramesh. “You can’t breathe in there!”

“Actually, I can, for about ten minutes. That’s plenty to walk around and inspect crops. I do almost all my work inside the tractor cab, which is pressurized to 0.15 atmospheres oxygen plus humidity and traces of carbon dioxide and nitrogen that drift in from the enclosure. Spiderbots do any picking, but I usually stick to wheat, corn, and other things that can be harvested from the tractor cab.”

“I see; just like the clover and other things in Highland Meadows.”

“Exactly, like the clover.”

Ramesh had referred to the topsoil he thought Kristoff had stolen from his enclosure. He was getting angry, but he took a breath. “Look, I need to test our new pile driving system somewhere, and Ukraine is perfect. It’s August; we’re finalizing our orders for parts for launch in the next four months, so they can get here fast. We’re pretty sure our new system will allow enclosures of literally infinite size; they’ll just need pylons every 100 to 150 meters. We may even be able to develop an enclosure whose width can be increased incrementally. This is quite a valuable innovation; one could even call it a breakthrough.”

“How about this, then,” said Lisa. “What if you emplaced one pylon in Agmar’s portion of Ukraine? Kristoff has two sevenths; Agmar has the rest.”

“Of course, I’ve been leasing a lot of it!”

“But we do own it.”

Kristoff scowled and glared at Ramesh. But Ramesh wasn’t glaring confrontationally back at him, so he calmed. “You know what I’d like. If we raised the

pressure in Ukraine to half of standard—0.165 atmospheres—mostly oxygen, and let the humidity cycle up and down to as high as 0.05 atmospheres in addition, total pressure would still be 0.215 atmospheres. The system was designed for 0.11 with a three hundred percent redundancy, so theoretically it can handle 0.33, or standard Martian pressure. So 0.215 should be fine. People don't live in here and we don't have to worry about fires, which could push the pressure way up quickly. Isn't a fifty percent margin sufficient?"

Ramesh shook his head emphatically. "No, it isn't. Dome materials age and fatigue over time. Everything is on a standard maintenance schedule that assumes a three hundred percent margin."

"But what if you raised the dome's capacity to two hundred percent of 0.215?" suggested Lisa. "Emplacing a few pylons would be sufficient to do that. You'd be able to test your system and we'd get a breathable environment that is off limits to casual visitors."

"And you'd test your new system for less money," added Kristoff.

Ramesh wasn't happy, but he paused to think. "I'd still need to emplace three groups of pylons. We'd have to spend some money to redesign our plan—"

"You made your design before approaching us?" asked Kristoff.

"Not completely! We ran a preliminary design through our engineering software. We could do that again in a few sols. Alright, we can try that."

"This is a workable compromise," said Lisa. "I think it may be better for the agriculture as well; a low pressure environment is not great for some crops. We've added thousands of extra tonnes of water to this enclosure while irrigating because it's cheaper

than desalinating and recycling the water here; this place must have three tonnes per square meter by now!”

“You really need to be desalinating, though,” said Ramesh. “The nickel-steel is almost as good as stainless steel, but it does corrode over time, especially in a saline environment.”

“Can you add that to your budget?” asked Kristoff.

“Tell you what, we’ll throw in new desalinators,” replied Ramesh. “I suggest you approach the borough and ask them to handle the maintenance, because it has to be done properly. We don’t want another accident like Aram’s.”

The landing of the *Korolev* on Titan was the occasion for Acheron Outpost's first banquet. It was mid August; the Von Braun had landed almost a year earlier and there had been plenty of time to set up the underground outpost. Johnny Lind was very impressed by the wide variety of fruits, vegetables, grains, and fish available, not to mention ample vegetarian steak and real steak drawn from their extensive stores. Yuri had even decided to provide dozens of liters of wine from their stock.

As the crowd finished its meal, he rose and rang a small ship's bell. "May I have everyone's attention," he said. He paused, then said, "We are celebrating the successful completion of phase one of our exploration of the Saturn system. Over the last eleven months, Johnny Lind and his crew of fifty scientists and engineers completed our exploration of Enceladus, spent six months on Iapetus studying the evolution of that body, and three months characterizing the geological history of Rhea. They visited three of the four Saturnian moons we have visited. Some members of the crew were also

involved in the study of Saturn itself via the dozen satellites in orbit around our primary world. The crew has exceeded all expectations in their accomplishments and have completed one hundred fifty percent of their nominal mission. Johnny has a lot to with this success; his leadership, drive, and vision kept the crew focused, kept their eyes of the prize, and defined their success. Johnny, please rise to receive our gratitude."

Lind rose, smiling and pleased, and everyone in the great hall applauded him. "Will the moon crew rise as well?" asked Yuri and the fifty rose as well. The applause redoubled.

"Thank you," replied Johnny. "We had a great year in Saturn space and I anticipate phase two will be just as great. Over the next two months we want everyone to help us analyze the data, draw new conclusions, and shape the plans for our next foray. After centuries of telescopic study and a century of visits by probes, no one yet knows how many moons this planet has! There are a dozen significant moons to visit yet, several distinct satellite families to explore and characterize, captured Kuiper belt objects to study in detail--much easier to visit than the ones still in the Kuiper Belt!--and of course we have to visit the rings. Think of the science and exploration we'll be doing in the next few years! I look forward to working with many of you to accomplish many significant milestones in the history of the Saturn community." Johnny sat to further applause and a few cheers.

Yuri looked at Sridhar, who looked back at him. It was a good speech, but the moon crew was exhausted and most wanted to stay on Titan. Furthermore, Johnny's drive and vision had accomplished so much in sometimes unpleasant ways; many didn't want to serve under him again.

Everyone went back to eating, but the ice cream had been consumed and many of the coffee and tea cups had been emptied. Families began to drift out; Titan now had 73 children in addition to the 301 adult crew, three of whom had arrived as children. The outpost was filled to capacity.

Yuri rose and walked to Johnny's table. Lind was finished with his supper and was talking to his son Tad, who was now seventeen. "Can we talk?" asked Yuri.

Lind shrugged. "Sure."

"Let's go for a walk."

Lind nodded and rose. He followed Yuri out of the great hall, which occupied a thirty-five by twenty meter section of bubble N-4. It had a six meter ceiling, enhancing its spaciousness and making it useful for some vertical exercises, which required a lot of headroom in Titan's one eighth gravity.

Yuri led him deeper into N-4 to a spiral ramp upward to the "surface." As they climbed, the stair passed three levels of vegetables, wheat, corn, sorghum, and rice. Agbots were nurturing and harvesting crops as they went; N-4 provided a fifth of Acheron's food. It had room for several additional levels, but the space had been left unused for now so that the station could be spread out among as many bubbles as possible.

They reached the top of the spiral ramp and opened a door into the flat "ceiling" of N-4. They entered a thirty-five by seventy-five meter space with an icy-white ceiling twenty-five meters overhead. The floor of the space was a park with several groves of trees—not all fruit and nut trees, either—and gardens growing herbs, flowers, and vegetables. There was even a large patch of tall grass.

"It's beautiful," said Johnny, taking a deep breath. Then he looked up. "The ceiling's a nickel-iron plate? All I see is ice."

"It's painted white and frost has covered it. The ice cliffs are covered by Kevlar nets to keep everything in place, but you can't see them, either."

"And the system has prevented further ice falls?"

"Yes, completely. I hope you enjoy it while you're here. I know most of the moon crew was starved for greenery."

Johnny shrugged. "Not me. A few days of it is all I need every year or two."

"That's what we need to talk about; the destination of the next mission, its duration, and the equipment used."

Johnny nodded. He walked to a grove of citrus and picked a ripe orange. "As I said, I don't know the destination; we need to make a team decision about that, don't you think? I'd like to go to Phoebe next. We can be the first ones to visit a Kuiper belt object—"

"It's a long way out and retrograde, which will make rescue ability difficult."

"Don't be fooled by the retrograde motion; it moves only about a kilometer per second around Saturn, so the delta v is small. As for rescue capability, with the *Korolev* and the *Santa Maria*, it's hard to imagine a situation where rescue capacity would be needed."

Yuri looked straight at Johnny. "That's part of what we have to talk about. You won't have the *Korolev*. It needs to stay here. We need it for the outpost. The kids are growing and they need more gravitated space. You'll have the two caravels, though."

"Yuri, you promised me the *Korolev*! You can't take it back now!"

"Johnny, I never said you'd have the *Korolev* forever. When we arrived here, we didn't know whether we would stay or evacuate, so it made sense to keep one galleon in orbit *until the crisis was over*. But we now know the *Cassini* will leave Mars next March—seven months from now--and will arrive here in the summer of 2074, plus or minus a few months. It'll bring us fifty to one hundred fifty personnel, depending on how many of us decide to leave. It may bring a third caravel as well, to strengthen our exploration of the system. Both galleons need to be stationed permanently on Titan from now on."

"Yuri, how can we plan anything without a consistent plan involving a long term commitment of equipment and personnel!"

"How can we make a consistent plan when Earth might have blown up? Two caravels accommodate fifty people perfectly and either one can accommodate fifty in an emergency, so this is hardly a limitation on the exploration plans. You don't need a galleon; its standard accommodation is 150. Clearly, we need it here. The bigger problem will be finding fifty volunteers. My guess is that the next mission will involve twenty-five. What I hear is that a lot of people don't want to go out again any time soon. Almost all of them have spouses and children here."

"Well, you've heard things I haven't! I've heard a lot of people say they want to go out again."

"Good. Excellent. If you get fifty, that's fine. They'll fit in two caravels fine. One other thing: Phase two will last no more than six months. No more one-year missions. They aren't necessary. Go out, visit one or two worlds, come back here in six months or less; analyze, interpret, assemble a new team; go out for Phase Three; etc."

Johnny scowled at that and didn't reply.

"That's the way it's going to be, Johnny. We need the caravels to explore Titan, too; they're the only vehicle that can provide a safe haven on the surface. This is a rational allocation of resources, considering our situation and upcoming resupply plans. If the latter change, the allocation has to change."

"I think you're trying to limit my possibilities for success."

"I told you exactly what I thought of your possibilities back in the dinner. You have vision, drive, and single-mindedness. I'd even say you have genius. But Johnny, you can't expect a lion's share of our equipment and resources. If you drive people too hard, you won't have any volunteers. And if you are insubordinate—which you haven't been, I should add—I'll ask you to take your career elsewhere. It sounds like Uranus will need a commander in a few years."

Johnny's angry face softened. "Alright, Commander, I hear you. A six month mission with two caravels in two to four months; how does that sound? Do you object to Phoebe?"

"Not if the mission plan passes review."

"Okay, fair enough." He looked around N-4's groves of trees. "I guess I need to enjoy the greenery for a while."

Will rocked Shayda and hoped the little girl would go to sleep quickly. He no longer had the patience he used to have with babies. But she was so cuddly and warm, he found himself holding her tight anyway and was getting a bit sleepy himself. So he headed to the house's front airlock and stepped into the tunnel. Shayda stirred at the cooler air, but

the walking motion calmed her, too. Will headed to the dome of the Baha'i temple and walked her around the building in the garden for five minutes, always aware of the rain of cosmic radiation descending from the heavens on his tender grand daughter. Finally, she fell asleep. He headed back to the house, and fortunately the change to the house's warmer air didn't disturb her. He put her down in her crib and she stayed asleep.

He had maybe an hour before she awoke, so he pulled out his tablet. Just as he was about to pull up his email--he had a constant stream--the tablet chimed with an incoming call.

Tree Rivers, the prophet in charge of Aram Outpost, or as they preferred to put it, "Aram Oasis." He didn't hear from Rivers very often. He activated the call. "Good sol, sir."

"Good sol to you, Chief Minister Will. I'm sorry to call you on a Satursol. Is this a good time to talk?"

"Yes, if our conversation doesn't awake my grand daughter. How can I help you? Are you calling about the new enclosure technique?"

"No, I've already had a long conversation with Ramesh about it, and he told me about the web sites where we could find the latest information. We'll follow his work closely and have already ordered the parts for a new robotic pile driver they'll assemble for us. Aram definitely needs the larger enclosures. No, I called to inform you that the New World Community has now purchased a caravel of its own."

"Really? How's that possible?"

"The Marsian government isn't the only beneficiary of high gold prices. We invested heavily in Martian gold stocks and quadrupled our endowment, in spite of the

terrestrial depression. Brazil needed cash to rebuild its spaceport and we were willing to buy the *Pedro Álvares Cabral* at a good price. And we got one. So we are now in the position to import up to 150 members this columbiad. I'm calling to talk to you about the implications. We have to get our people to low earth orbit, we need fuel, and at this end we need to get them to the surface. We don't need pilots; the Brazilians will supply them. I gather you'll have the galleon *Isidis* and three pairs of caravels heading to Mars in October, November, and December."

"What will you do with them all? That'll more than double your population!"

"We'll put them to work! With the new robotic pile drivers and more construction people, we'll be able to build enclosures and green the Aram plateau faster than ever. We might even offer some berths to the Zen monastery; we know they want to import more monks, but have no money. They've been good to us, as have you. Do you think we can launch at the same time as one of your caravels and accompany it to Mars? I'd prefer we're docked to a caravel. Even if we are near one, they can provide us rescue capacity, and we might be able to help them as well."

"I'm sure that can be arranged. That's simple and straightforward. You won't have trouble buying propellant because the moon's tanks are full, as are the tanks at Gateway. The Australian shuttle is scheduled to launch personnel for us one day a week, but they have begged for more business, so I am sure you can sign a contract with them. The European shuttle is pretty busy launching materials to expand Ibis and add industrial capacity to it, so they won't be interested in your business."

"What about the Japanese?"

"They keep saying they're going to go out of the shuttle launching business, then they promise to rebuild their spaceport. But I wouldn't count on them for this columbiad. Do you plan to use your caravel to import 150 people every columbiad?"

"We may go into the immigrant transport business, yes. But we also want to send out a mission to an asteroid if we can find the right one. Many years ago in a vision I saw a terraformed asteroid. I think I told you about it. If we found a carbonaceous chondrite body in the right orbit about 300 to 400 meters across and we could buy a 500 meter spherical dome, we might just do it! With the caravel, we'll have the launch capacity. If we burrowed inside the asteroid, we'd have the shielding to live there just fine, and we'd be able to extract all the volatiles we needed to make an atmosphere and establish life. It would be quite an accomplishment; we'd bring an entire world alive. That remains a long term goal."

"But you'll need to acquire a lot of capacities before any government would allow you to launch such a mission."

"True. But once we launched such a mission, we'd be a sovereign nation all of our own. That would be quite something, too. We'd have a voice at the table."

"That's a seductive vision, isn't it? Anyway, don't contact me for specifics in a contract. You need to contact our Minister of Immigration."

"I know. I called partly to tell you the news. We may even have berths for your program. We will know in a few weeks."

"You need to hurry, launch is in just three months. Let us know if you have space; no doubt we could use it."

"We will. Best wishes, Chief Minister Will."

"Thank you, same to you. Bye." Will closed the line and leaned back to contemplate the Green World Community's ambitions. He had thought long ago that they had given up the idea of terraforming an asteroid and wondered who would supervise such a project. "Anisa, what's the surface area of a sphere with a diameter of 500 meters?"

"It's 196,250 square meters."

"And what would the mass of one of our enclosures be if it had that size?"

Anisa thought a moment about that request, probably to be sure she understood the grammar. "About 300 tonnes, plus a similar mass of cables."

"Thank you." So, the idea was difficult, but feasible. "How many carbonaceous chondrite asteroids orbit between Earth and Mars with an average diameter of 300 to 400 meters?"

"Six."

"Do any approach within ten million kilometers of Mars in the next five years?"

"Two."

"So, it could happen. Thank you, Anisa."

He turned to his email for half an hour, then Liz returned with Jason. "Is Shayda asleep?"

"Yes, she fell asleep almost an hour ago."

"Good. You have a nack, dad."

"What did the doctor say?"

“The vaccines are helped a lot with Jason’s allergies and even with his asthma, though he got several more shots today and is not a happy kid. He may also feel sick tonight.”

“The penalty we pay for not living close to animals on germ-filled farms.”

“Yes, though our levels of allergies and asthma aren’t much worse than urban Earth, so I guess we have enough germs! Can you help me get Shayda back home?”

“Sure.” Will gently picked up his grand daughter and put her against his chest; carrying a 14 month old in Martian gravity was easy. Liz picked up Jason, who was still upset by the shots and refused to walk.

“Did you hear there’s been another terrorist attack by the White American Christian Militia?” she asked.

“Yes, I saw it in my email. We’ll condemn it, of course. They’re proving a pretty tough cell to eliminate.”

“The country is so polarized and there are so many people taking extreme positions, they have a lot of sympathizers who won’t cooperate with the FBI.”

“It’s sad. We’re definitely better off here, where we can focus on something of enduring significance to humanity. Is everything on track to start the Dawn Dance Academy on September 1?”

“Yes. I’ve already got twenty kids signed up, we have Martech’s performance hall reserved for December 20, and Madhu has asked me to take over most of her duties as Coordinator of the Arts, so I have too much to do, if anything!”

“You’ll have the rest pretty soon, too, since she’s retiring in the spring, when she turns 75.”

They walked the rest of the way in silence. Will put Shayda in her crib, which woke her up, and left Liz to deal with the resulting cries. He headed to the Gallerie to do some shopping for the house.

The two stores were reasonably busy, for a Saturday afternoon. People were no longer saving money and the stores were putting all of their stock out in anticipation of the resupply coming every month by fast capsule—the Commonwealth had paid the extra shipping—and by solar sailer after that. Will entered Silvio's to buy toilet paper, a canister of Marjeeling tea, a box of sugar cubes, and bagette of bread. He found himself at the autocheckout right behind Jacquie Collins.

“Stocking up?” he asked.

“Yes, Tithonium's store doesn't have the variety, and when you order it ahead of time you aren't really sure what you're getting.”

“How's Mario and the baby?”

“They're fine. Mary's talking a lot now; she just turned two. How's Ethel?”

“Good. Back at Uzboi for a few days to help solve personnel problems caused by the return. A lot of people had boyfriends, girlfriends, or new spouses in Cassini or Dawes and now that tangle has to be resolved. But PGM production is coming back up, and the price on Earth is picking up, even though Parenago is back in production as well. Looks like Tithonium's switching to chromium and aluminum.”

“Yes, with the gold price sagging, we're better off providing strategic metals for the expansion of construction, especially ships and nuclear power. The ground breaking for the hotel is December, too. A lot people have already inquired.”

“And they have a lot of accumulated vacation, thanks to the emergency. You’ve been getting to Aurorae a lot lately.”

“I can do a lot of work for the Mars Council at home, but a face to face with staff and some legislators—and you—once a month has proved really helpful. We have some good legislation moving forward. I think the development plan will help a lot.”

“Yes, I’m impressed. Everyone has been pressing for a document that states which borough will grow, whether Aurorae will remain dominant, and when we’ll plant more boroughs. I think the list of principles in the document is sound.”

“It’s flexible, too, because every borough wants and needs to push its own interests. I can’t see any borough surpassing Aurorae, frankly. Mineral prices are unpredictable. Aurorae has the most economic diversification. Pretty soon we’ll be getting you a document stating the principles for the creation of planetary parks, too, with some specific suggestions.”

“I liked the earlier draft; it was very promising. You’ve been really activating the Mars Council, and I’m appreciative of it.”

She nodded. “Thank you. Someone needs to do it. The Chief Minister, as the executive officer, probably shouldn’t do it. The Council’s chair could do it, but Lal doesn’t seem inclined. The Council’s only other officer is the Clerk, so I have been gradually trying some new things, and Lal hasn’t objected to it.”

“No, he’s been supportive. His glaciology research has been pretty important to him, with the new textbook taking shape, so he has left the organizing to me.”

“Let me know when you’re going to be in town next, especially if Mario comes along. Ethel and I would love to have you over for dinner.”

“Thank you, you’re very kind. It’ll be five weeks, I think; early October.”

“We’ll see you then, then.”

4.

The Prize

October 2071

“It’s so good to hear that, from a health point of view, the emergency is over,” said Will.

“Thanks, Simin.”

“Well, I wouldn’t equate a resupply of medicines and vaccines and a drop in need for psychological counseling with the end of the emergency,” said Simin. “Remember, people are still immensely anxious about their terrestrial relatives, stressed by shortages here, and uncertain about our future.”

“I concede that,” agreed Will. “But I was referring to the drop in the need for counseling. That’s important, I think.” He looked around at the other cabinet members.

“Hun-jai, what’s your report?”

“The terrestrial expenses for the rest of fiscal 2071 are thirty percent over budget,” Park replied. “But it is our policy to let them overrun by up to thirty percent because we have so much cash on Earth and we have sufficient launch capacity if we pay for it. Our Mars Development Endowment is on track to be fully incorporated and functioning in four nations by December and we should have branches in eight other countries by June. It should help buffer the drop in income we anticipate in the next few years. Henry wants to spend up to a one hundred million redbacks and I think it’s a good idea.”

“Actually, I want to spend up to three hundred fifty million, but Hun-jai only thinks 100 million is a good idea,” replied Henry. “Four hundred redbacks per kilogram is

a lot of money for private businesses to pay to import machinery, especially since they're still recovering from the crisis. I propose that if anyone wants to import machinery or equipment to develop their business, we subsidize the launch costs and keep them down to fifty redbacks per kilo. A thousand tonnes of equipment would require 350 million redbacks of subsidy."

"I doubt businesses would want to import that much, so I think we should set a reasonable limit on each business, and make a different arrangement for big public corporations like Marcraft, Marbuild, Marchem, and Marcomm," said Hun-jai.

"So, you aren't talking about imports for commercial sale?" pressed Will.

"No," replied Henry. "We're not talking about subsidizing the import of Barbie dolls, but of the molds and equipment to make Barbie dolls."

"We want to keep the price of imports for commercial sale high," said Hun-jai. "That will keep the Marsian public in the habit of buying local, and in the next few years commercial production should be able to expand to make just about everything we need."

"Except electronics," injected Emily, the Minister of Development.

"Maryam Salih would probably import fifty tonnes of equipment if she could," said Henry. "She now knows exactly what needs to be made here for high quality clothing and she's determined to set it up herself, if she has the money. I wouldn't be surprised if businesses import over five hundred tonnes."

"I think it's a good idea," said Will. "I suppose the question is: why not import them next columbiad when the price is sixty redbacks per kilo anyway?"

"Because the businesses will then expand based on demand and they'll need to hire," said Henry. "They'll advertise on Earth for positions they need to fill and have the

time to hire before the next columbiad, and we'll have to subsidize that, too. That's how we'll expand our consumer sector."

"It's expensive, but it's consistent with our immigration policies," added Hun-jai approvingly. "If we can subsidize the immigration of geochemists for Martech or engineers for Marbuild, we can subsidize the import of textile equipment or plastic intrusion specialists."

"Okay?" said Will, looking around. No one objected.

"This segues into my report," noted Yevgeny. "Lufthansa wants to lease three caravels belonging to the Venus and Mercury Commissions. They want to launch them to Mars at the end of November with Sunfire solar thermal engines and fly then here in three months; a very fast trajectory. They figure twenty-five cubic meters per person is sufficient on such a fast trajectory if they provide very large inflatable zero-gee facilities for exercise and hanging around space."

"That's three hundred people in each caravel!" said Will, shocked.

Yevgeny nodded. "Nine hundred altogether."

"Could they get that many people into orbit in eight weeks?" asked Henry, surprised.

"They'd fly people here who are on our waiting list, which has 1,500 on it," replied Yevgeny. "The bigger problem would be launching them to orbit; the Category 5 hurricane that just wiped out the southern half of Florida has Kennedy shut down for at least six months, and the magnitude 8 earthquake that hit northern California in August has Vandenberg shut, and we're already using almost all of the launch capacity of West

Texas and some of Hainan's. So Kourou, Australia, and Kenya would have to handle the volume. They'd charge a lot, too; probably 2 million redbacks per passenger."

"Too much," said Hun-jai.

"We're planning to bring 1500 here on our galleon and six caravels on four-month trajectories," said Will. "That's 1,000 new citizens, plus 300 to replace the ones who left, and 200 for the new Saturn expedition. Plus the Green World Community's caravel will bring 150, but we have no control over their immigration. We promised to keep our immigration to 1,000 this columbiad. If we say yes to Lufthansa, we'll break our promise."

"Two thousand would be a huge strain," said Emily. "We have managed to increase our enclosed space per person to 120 square meters, even including the 1,000 immigrants already scheduled, and we want to increase it to 135 square meters by 2074. Another thousand people will push our enclosed space downward to 110 square meters per person instead. We'd struggle to make the housing and furniture."

"Too much chaos," agreed Will. "The answer to Lufthansa is no, this columbiad. It's absurd they'd propose such a mission at this late date, anyway. We need a safety review of the plan. They want to charge too much, too. Next columbiad we can have a huge immigration, but we'll have time to get ready."

"And our businesses would have time to plan their hiring," added Henry. "If they import lots of machinery this columbiad, they'll need workers to run them next."

"What else?" asked Will, moving to the next item on the agenda. "Yevgeny, the *Sagittarius* has reached Callisto safe and sound."

“Yes. Nothing to report, other than a huge welcoming dinner and excitement like nothing we can manage here on Mars. The jovian system’s capacities are now pretty well restored, with the arrival of cargo from Earth last month.”

“But I gather the Chinese are uneasy about the situation because they weren’t able to match our effort, so we have to watch that one. “Moses, how’s road building?”

“We’re back to full operations. We’re eighteen months behind the original schedule, but with new equipment we should be able to catch up over five years. The Dawes-Cassini Highway upgrade will be done this December and will permit eighty kilometers per hour the entire way. The Aurorae-Tithonium Highway will be started next.”

“Do we really need metal paving, when most vehicles can’t even manage 80 kilometers per hour?” asked Hun-jai.

“The primary benefits are safety and fuel efficiency,” replied Moses. “Metal surfaces allow use of truck trains. They can be one hundred meters long. This is especially important for Uzboi because they produce almost a million tonnes of iron and nickel ‘waste’ every year and they’d like to convert it into usable items and export them down a good road. We can use the free liquid iron and nickel carbonyl byproduct to manufacture the paving units. We plan to import four largely automated road building systems, which will cost about a half billion redbacks on Earth for development and production. A crew of fifty here can keep them repaired and operating and can provide the metal paving units. They’ll pave 650 kilometers per year each if there’s no down time.”

“We really could use the highway upgrade,” said Jacquie Collins. “Right now, surface transport is limited to fifty kilometers per hour and twenty tonnes at a time.”

“But metal highways will also favor the growth of Aurorae until the system is expanded to the Central Highlands,” noted Emily.

“Cassini has a lot of waste nickel-iron and could be a second source for manufacture of metal paving panels,” replied Moses. “It’s too bad Dawes didn’t do much PGM production, because it’s centrally located and metal highways could be built from it in three directions at once. I suspect in ten or twenty years we’ll have a metal road all the way from Aurorae to Meridiani, Dawes, and Cassini. Several billion redbacks in automated equipment will be needed, but the road construction team will total maybe fifty workers, just as it does today.”

“The need for pressurized metal modules, pipes, pylons, and paving panels is such that all the major outposts already produce some PGMs just to get the metal they need,” said Emily. “So I am sure Dawes can expand its PGM production.”

Just then the door to the cabinet meeting opened and Jacaranda stepped in. “I apologize for the interruption,” she began. “But the Nobel Prize for Physics has just been announced, and one of the winners is Jose Suzuki.”

“Really!” exclaimed Will. “For his interferometry work?”

“Exactly. He shares the prize with a colleague at Keck Observatory, Hawaii, and with the chief astronomer at Peary. The synthetic aperture system they developed using the Olympus Mons telescope array with arrays in Hawaii and Peary produced a virtual aperture of sixty million kilometers. With more light gathering power, it should be able to

see almost into the heart of the Big Bang, not to mention the resolution of details on the surfaces of extrasolar planets and all sorts of other possibilities.”

“Nobel Prize number two for Mars,” commented Jacquie Collins, pleased.

“Prepare a public statement right away,” said Will. “We should probably adjourn anyway, because some of us will want to go to Martech to congratulate him in person.”

“It sounds like we’ll have to add a hundred million redbacks to expanding our astronomy facilities, too,” added Hun-jai.

Amy Elliott paused to inspect the new simulated soil that the robotic truck had spread over a section of S-4’s park surface. South-4 had been inflated just two months earlier and the bottommost and topmost floors had been installed. The topmost floor would be the surface of S-4 “park,” the open top half of the bubble. Eventually, several more floors would be installed underneath. She reached down and picked up a handful of the simulated soil. Half of it was gray flecks of ground up chondrite that had been roasted to break down the crystals. The flecks were crumbly, would absorb water, and would release minerals to the plants easily. The black flecks were charcoal-like, made by taking tholin hydrocarbons and roasting them into carbon; they absorbed water and plant organics easily. The truck had deposited a very uniform fifteen-centimeter layer on top of fifteen centimeters of crushed chondrite, which covered the thick plastic tarp over the stainless nickel-steel surface. Before planting, they’d add a centimeter or two of composted vegetation with worms.

“This has a pretty high char content,” she said, watching it pour through her fingers.

“They increased the tholin content,” replied Guanya. “The chondrite supply is getting low again.”

“We’ll need to cut more tunnels and caves, or go excavate some lag deposits. We can add compost and water to this section and plant wheat this afternoon.”

“Great.”

Just then, they felt a shaking and heard a rumble. They both instinctively looked up at the flat ceiling of the cave and at its gleaming white walls. The shaking wasn’t serious and ended in a few seconds.

“Whew. Nothing fell,” said Guanya.

“It’s probably part of the eruption of Paricutin cone,” said Amy. She pulled out her communicator and popped up Marshall’s GPS data. “Marshall’s out there right now with the geothermal team.”

“It’s screwing up the geothermal well,” replied Guanya.

Amy nodded. There was another long, feeble shake, so she called him. “Hey, are these quakes coming from Paricutin?”

“No, from another cone ten kilometers farther west in the Likoma complex,” replied Marshall. “So, you felt them? The shaking was pretty bad here. If it had been Paricutin, we’d be fleeing, believe me.”

“Are you leaving early?”

“No. We’re almost done shifting the pipes to the new shaft, so the hydrothermal power generation should resume in a few hours. In spite of all the trouble, the storage trailer here is just about full of liquid oxygen. I think a robotic truck can come get it in a few days.”

“Good, we need the power if S-4 is to be illuminated properly. I was worried about you. See you tonight.”

“Tonight. Bye.”

They both closed the circuit. Marshall looked around and saw Surender Subrahmanian approaching with a sample of dark ice. “What is it?” he asked.

“It’s a xenolith that I pulled out of the ice-lava flow in the side of the ravine.” He pointed to a nearby ravine he had just come out of. “I spotted it last week when exploring via my Android-150. It appears to be dredged up from the base of the crust. We don’t get many of them.”

“So, it’s got biotics from the mantle ocean?”

“I’m pretty sure. I’ll be positive when I get back to the lab. It should help nail down a few theories we have about the organic chemistry going on in the ocean, especially in gas pockets on its top.”

“Still no microbes?”

Surender shrugged. “Just the titanobionts. They assimilate certain organics and they sort of reproduce, though that takes a thousand years, since they lack genetics! The situation here is very similar to Callisto, Ganymede, Europa, and the water bodies inside Ceres. The diversity of organic sources present on early Earth and Mars weren’t present here; no desiccation of organic goo in the presence of salts and clays, no lightning, no shock waves from thunderclaps, no ultraviolet light, just tholins slowly escaping into the ocean from the crust and thermal vents from the silicate layer underneath.”

“And ocean-bubble-ice crust interactions.”

“Exactly. We’ll have a better idea when we get the robosub in two years. The seismic data indicating a hundred-meter thick layer of biotic muck on the bottom is intriguing. The titanobionts seem to have ‘evolved’ and we need to recover ‘fossils’ of the earlier forms. The xenoliths are undatable, still.”

“Still, they have told us something about protolife.”

“Absolutely. The Galileans and Titan tell us part of chapter one, Mars tells us about chapters two and three, and Earth has the rest of the story of life. Wait till we get to one of the Earth-like planets near our solar system in a few centuries and see an entirely independent book; *that* will be interesting.”

“For our great grandkids!”

“At least!” Surender laughed at that and continued back to the mobilab to store the sample in a special container. Marshall turned back to his job of bolting the methane gas uptake pipe to the pipe leading from the uptake shaft. Chad Sutton was working on the liquid methane downput pipe ten meters away. It was tricky work in heavy gloves with metal tools that were brittle in the cryogenic cold. They both paused three times when temblors shook the area.

Once they finished, they retreated into the Mobilhab and tested both connections by pressurizing them with nitrogen. There were no leaks, so they started the flow of liquid methane down the hole. In a few minutes gaseous methane came out the uptake and the turbine began to spin, powering an electrolyzer. The hydrogen was released into a tank full of tholin, where a small amount of oxygen to make a flame started a chemical reaction to hydrolyze the tholin and store the methane and ethane for later use.

Surender and his geological team returned and entered as well. Just as they were about to head home, a news flash popped up on Surender's communicator. "Wow! Vanessa Smith Hunter just split the Nobel Prize in physiology with two eobiologists, Molly Armstrong and Jiang Liu on Callisto, for their work on Martian life and Galilean bionts!"

"Really?" said Marshall. He turned to the screen near him and called up the news report there, so everyone could see. "Vanessa's such a great lady, and an excellent eobiologist."

"She helped train me!" agreed Surender. "So, a Nobel Prize for chapter 1 of life on Callisto and chapter 3 on Mars, and Tang Enlai's Nobel was for chapter 2 on Mars!"

"I suppose that leaves out our research here," said Chad Sutton.

"Probably," agreed Surender. "Unless we can come up with some clever applications for medicine. It's a Nobel for medicine and physiology, after all."

"Now it's two Nobels for Mars in two days," added Marshall. "Three altogether."

All of Mars celebrated Vanessa's Nobel Prize. Its eobiological research was much better known than its astronomical work; the latter was an international collaboration while the former was Mars-based. Vanessa was at her office at Elysium Outpost when the prize was announced, but she flew to Aurorae three sols later for a big public gathering in Andalus. José Suzuki, who coincidentally had been on the annual maintenance visit to the Olympus Mons observatory, was back in Aurorae as well.

Both Nobel laureates spoke briefly to the crowd, which numbered nearly half the outpost's population, thanking Mars for its devotion to research. Then Will went to the

stage to congratulate them both. “These Nobel prizes demonstrate that Mars has come of age as a nation,” he began. “We may be small, but we have a remarkably capable citizenry, and our impact on humanity is growing. A typical developed nation on Earth spends a third of its government budget on retirement and the health of retirees; we spend almost nothing and allocate this slice of our revenue to immigration instead, resulting in a huge population of young people to cover the costs of the few elderly. A typical developed nation spends five percent of its gross domestic product on education; we spend almost twice that, including graduate education. That guarantees we will have the most educated and capable population of any human community in history. A typical developed nation spends five to fifteen percent of its government budget on defense; we spend it on research and development, including exploration on and off this world. These Nobel prizes reflect our priorities; no doubt they won’t be the last prizes our science and engineering teams will win. Our medical community is exploring the mysteries of cancer and aging because we are the most extensively studied population in medical history. Our economic team is innovating new ways to manage a post-industrial robotic economy and managing cash flow between planets. Our social and political systems are surprising and confounding many experts and causing them to rethink many of their fundamental assumptions. We can expect that Mars will continue to be recognized for its many achievements and will play an important role in the progress of humanity. This sol we focus on the achievements of our two latest champions. Congratulations to them both.” He extended his hand to Vanessa and then to José while the crowd rose and applauded.

“Congratulations,” he said to Vanessa.

“Thanks, Will. The support of the Commonwealth has been really valuable and consistent, and we appreciate it.”

“We have to figure out how Martian life works and revive the old ecology; we can be its savior, and it may yet be ours,” he replied. He turned to José. “When I heard you won the Nobel, we adjourned our cabinet meeting and headed to your office to congratulate you, only to discover you were still at Olympus!”

“Sorry about that! We were already on our way back down the mountain at the time; the maintenance visit usually lasts only a few sols. I was in the Mobilhab when they called me. It was the middle of the night. They thought I was at Aurorae and couldn’t understand why I didn’t respond, so the Nobel Committee was emailing everyone they could asking them to ask me to check my videomail! It was a bit confusing.”

“I guess that’s why they contacted me an entire sol early,” said Vanessa. “They hadn’t accounted for the potentially slow communication between planets!”

“That’s interesting,” said Will. “I was impressed to think that the two eobiologists on Callisto who shared the prize with you, Vanessa, were also here several years and were trained partly by you. Our impact extends to those two prizes, too.”

“And Enlai’s impact,” added Vanessa. “He trained me and helped to train Armstrong and Liu. His was the first Nobel Prize we got, and it was his insistence that our papers about Martian life or Galilean bionts always include something about physiological and medical applications of our work. It’s the Nobel Prize for medicine and physiology, after all, not for biology.”

“But it wasn’t just a propaganda thing; it was also an insistence on interdisciplinary thought,” said Will. “Enlai has always been good that way.”

“I was fascinated that your talk put these prizes in a much larger context,” said José. “Even a congratulatory talk about Nobel prizes mentions our immigration policy!”

“Well, I don’t think people appreciate the impacts that our immigration policy has,” replied Will. “If we stop spending money on immigration, in fifty years we’ll be spending just as much money, but on retirement and elder health care! Mars has nearly 10,000 people, and only a dozen are over 65. When we have a thousand people over 65, Mars will have 100,000 people, even with a slower immigration policy.”

“Better than social security,” agreed José.

Will pointed to the entrance to the Gallerie. “Let’s go inside. It’ll be a *big* reception!”

“Something else the Commonwealth is doing from us,” said Vanessa, because the government was paying for the late afternoon gathering. They all headed for the entrance, behind much of the crowd.

Huma hurried over to Will. “You’re being paged. Jacaranda and I have both received emails from the Nobel Committee asking us to make sure you see their message.”

“Nobel Committee? I wonder whether they’re upset about something I said.”

Huma laughed. Will saw her response and sudden grew very serious. He walked over to the outside wall of the Gallerie, away from the crowd, pulled out his communicator, and found their videomail. Huma dashed over to Ethel to tell her of the message. When she began to hurry over to Will, she saw the shock on his face. He looked downward toward the ground.

“What is it?”

He didn't reply right away. She stopped next to him and put her hand on his shoulder. He looked up.

"The Mars diplomatic team has won the Nobel Peace Prize for its efforts to bring about the truce between the United States and China. The peace prize committee also cited our consistent support for internationalism, our vision of a united and peaceful humanity, and our efforts to build a just and prosperous multicultural society on the Red Planet."

"Really? Fantastic! Pete Theodoulos and Ruhullah Islami?"

"And me, as Chief Minister!"

"Really?" She squealed and hugged him.

"Thanks, but don't make too much of a scene, it won't be public for a few hours. Now I have to acknowledge receipt of their message. They're very concerned about the communications problem."

"Well, acknowledge them! And we have to go inside the Gallerie for the reception. Typical of you, to manage to attend a reception for Nobel prizes without being the focus of attention yourself."

"We won't throw another reception, too! One is enough."

"Three Nobel Prizes for Mars in five sols! And the committees don't talk to each other."

"I know, it's quite amazing. They asked whether I could come to Oslo to receive it in December, which of course I can't do. But this confirms to me that we are on the right course."

Will turned to his communicator, hit reply, and recorded a brief thanks to the committee for the prize. Then he and Ethel headed into the Gallerie to enjoy the celebration.

5.

Firebomb

Dec. 2071

All of Saturn gathered in the dining hall to watch the Nobel peace prize ceremony. Pete Theodoulos and Ruhullah Islami were both there to receive their prizes in person; Tang Enlai received Will Elliott's on his behalf. Even the Phoebe expedition, which had just arrived on that cometary retrograde moon, was watching in their two caravels, and their image was projected onto another screen in the hall.

Pete Theodoulos spoke briefly about the need for greater tolerance, understanding, and long-term thinking in international diplomacy—for what was best for humanity was often the best for individual nations as well, long term—then sat to vigorous applause. The afternoon crowd in Acheron's dining hall applauded as well. Marshall watched the scene with particular pride and looked at Amy and little Willie, now two years and two months old, frequently. When a videotaped statement of Chief Minister Will was played, he pointed and said “grandpa!”

When the ceremony ended, Yuri Severin rose. “I have already extended our congratulations to Will twice, and I will be sure to tell him of the pride we felt today. All of us are citizens of Mars, as well as of various nations on Earth and residents of the Saturn system, and I think we all feel proud based on all these different loyalties. Mars is a model for us. It may take a long time for us to begin to approach Mars in size; currently we have neither the propulsion technology, nor the economic basis, nor the settlement technology to make Titan as large and important as Mars has become. But I think it

remains our goal, even if a large fraction of us do not plan to remain here forever. We've now been in the Saturn system a year and a half. We have melted twelve caverns and emplaced twelve oxygenated bubbles. Housing, lab and work spaces, and ecology are under construction in eight of them. Three of them are virtually complete, that is, based on current plans, because all of them have a lot of unused capacity. Our housing space on the *von Braun* and the *Korolev* has been expanded and made more comfortable. Supplies will be on the way from Mars in a few months. In the next six months we'll finish much of Acheron Base, we'll make many important decisions about our goals here over the next few years, and we will all have to consider how long we plan to stay. I look forward to the discussions."

"They're sending a full complement on the *Cassini*, right?" asked someone.

"That depends on Acheron's capacity and how many of us plan to stay. We made a commitment to a five year mission, but because of the crisis on Earth, there was no third year personnel renewal from Earth. We're getting a turnover in the fourth year from Mars instead, and as it stands now the *Cassini* is our only galleon for interplanetary transport, and a round trip is four years, so we won't get another personnel flight until 2078. We're working on a sixth-year personnel flight using another galleon or a fleet of caravels. But it isn't guaranteed."

"This is a hard place to love," said Chad.

"It is," conceded Yuri. "A super-cold, reducing atmosphere requires a lot more care and a lot more technology than a relatively cold, thin, slightly oxidizing atmosphere. This is a much more dangerous place, it's dim, and it's exotic, which to some people just means strange. But some of us love it anyway."

There was a long pause in the conversation. “Then we have some thinking to do,” said Marshall.

The Nobel Prize ceremony and his taped remarks brought another round of congratulations to Will. His old friend David Alaoui was practically in tears when he sent his compliments. His sister Molly gushed in pride about her brother. Klaus Richter, the elected commander of Mercury operations, thanked Will for Mars’s broad vision for supporting exploration of the solar system and reminded him that they would soon get twenty-five new personnel to replace the ones who had returned to Earth. Commander Lavere of Magellan Station sent a short congratulation; the caravel had aerobraked back into Venus orbit just ten sols earlier and a new supply of surface and atmospheric probes had arrived from Earth, so they were back in business. “We will never forget the generosity of Mars and particularly Phobos Outpost,” she said. “Phobos and Magellan are now sister outposts. Our hope for a small asteroid captured into a high Venus orbit has been reinforced. It would give us a permanent shield against cosmic rays and solar storms, make this place permanently inhabitable for families, would give us a supply of natural resources, and would even give us some “outside” to visit. I hope we can explore this option with you in the next decade. If Mars could arrange for this, and if we can reinforce our contact permanently through regular exchange of crew, I think Magellan would opt to become an affiliated outpost with Mars, a sort of Martian Lichtenstein. I think we need to explore this possibility quite seriously.

“At any rate, congratulations again, Will. Keep providing leadership! Bye.”

Will thought about her plea, which wasn't new; in the last four decades commercial outfits had captured two very small asteroids and moved them to the Earth-moon lagrange point, and Magellan station had wanted one since its establishment. He taped a quick response and turned to President Bart Mennea's message. "I thought I'd congratulate you yet again," began the president, who had been an acquaintance in college. "Your speech about the invisibility of boundaries from space, the oneness of the Earth, and the obvious need to have a concern for all humanity first and for one's own nation second was very impressive. It was carried by our conservative media as well as by the mainstream and liberal outlets, and it generated considerable comment. Globalization has forced all of us into a neighborhood and we barely know our neighbors, in spite of instant communications. Your speech wasn't new, in many ways, but the timing was important. I'm sure your colleagues on Mars are reinforcing the message, too.

"Congratulations, also, on the peaceful midterm elections that Mars had last week. I have been told by my political advisors that while they don't know what to make of the results, everyone up on Mars seems pleased with how things are going. As you know, we take two steps forward and one backward down here. I dearly wish we could reduce the extreme polarization that characterizes American politics right now. As my reelection campaign picks up steam, I face profound dilemmas how to win the election and heal the country's divisions. Your prayers and good wishes for your native country are badly needed. Good bye."

Will made a few notes, then replied. "Thank you, Mr. President, for your warm words of congratulations and encouragement. I have been thinking at length about the political, economic, and social situation of the United States and wish there were simple

solutions. Healing takes time, and gestures of reconciliation are not always appreciated or accepted. But all our faiths urge us to forgive and move forward, and moving forward means working with our neighbors. The Grand Union is the best hope humanity has for solving its very serious mutual problems. Sea level is up half a meter since the beginning of the century and will rise half a meter more before the century's over. All the international agencies need to be rethought and realigned, just as they had to after World War II when the United Nations was established. Such a moment has come again.

“As for our midterm elections, if you want to understand our political process you can't just look at the election itself. Everyone was reelected; the first time that has happened. But deeper than that, you have to study the Future of Mars Forums, not just the face to face meetings but the internet discussion forums. Basically, they serve collectively as a gigantic focus group. We have software that helps us sort the discussion into tracks. It is clear that the majority of Marsians want immigration to continue after a partial lull this columbiad and that they want Mars to devote considerable resources to exploration of the solar system. They want more domestic production of consumer goods. They are split over the subject of creating life capable of living on the Martian range and over terraforming. Those are my four priorities and it is gratifying that the public is supporting them. We look forward to partnering with the United States on space exploration and working with you on many other projects of common interest, and I look forward to our continued conversations. Bye.” Will sent the message, which sat on his screen several seconds longer than he expected; a message flashed on the screen that said “delayed by internet difficulties” when it finally went. Mars communications had been subject to repeated cyber attacks in the last few weeks originating from terrorist groups in the

United States. He wondered whether, now that he had a Nobel Prize, the President would want to talk more. That would be nice.

He also had a video from Enlai Tang offering a quick, chatty description of things that happened behind the scenes at the ceremony. He closed with, “I wish we could sit, have a cup of coffee together, and catch up, Will. But I’ve decided not to come to Mars this columbiad. There are so many people in Beijing who want me to stay, give lectures, offer courses, even administer programs. And I’m now 63; I think I’m better off working a few years, then retiring here. Maybe I’ll come for a visit, and I hope you can stop by Beijing some time. Mars still owes you a free trip to Earth! I’m sure we’ll keep in touch. Bye.”

Will hit reply. “Thanks for the stories, Enlai, but I am very saddened to hear you aren’t planning to come back here. Mars needs you, too! But I understand. China needs its senior researchers and Nobel laureates, not to mention someone prominent in the exploration of two worlds. We’ll definitely want to keep in touch. I may need your advice and assistance in our collaboration with China, which can only grow in the future. Bye.” He sent the message and turned to other messages.

He turned to an email from Hun-jai Park detailing the various unexpected expenses of launching their immigrants to low Earth orbit; there were just two flights left and everyone would be on the way. He was starting through the numbers when Jacaranda Nuri hurried in. “Will, Molly’s house was just firebombed!”

“What?” Will jumped up from his desk. “Is it on the news feed? Is she okay?”

“It’s on CNN and reporters are calling for statements and background! That’s all we know!” She looked at him, terrified for her mother in law, Will’s sister.

“This is retaliation for the Peace Prize. Those bastards! The hateful, arrogant, cowardly bastards!” Will slammed his fist into his other hand so hard it hurt, but he barely noticed.

“Who?”

“Someone mad at me, Jacquie! Molly never did anything to deserve this! She’s just a harmless retired widow! Arrr!” He paced, angry.

“What do we do?”

“I don’t know!” He paced. “Molly will call us, but we should at least text or call her! You and Paul should do that; if she’s in the hospital, the doctors won’t tell me what’s happening, but you’re next of kin. Well, I’ll videomail her, too.”

“Statement?”

“Yes, but not yet, we don’t know enough. Go call Paul. Huma!”

“I’m coming!” She had been listening from her office. “I’ve got CNN on and they haven’t reported anything more.”

“Monitor the media outlets for Jacquie while she calls Paul and they call Molly.” Will turned to his desk and sat in his chair. “Anisa, a voice mail to my sister, Molly Nuri.”

“Okay boss, any time,” replied the electronic assistant.

“Molly, this is Will. We just heard your house was firebombed. Please contact Paul, Jacaranda, and me as soon as you can and let us know that you are okay. Thanks. Bye.” His voice had a quaver in it as he said the last word. He sat, staring out the window at Andalus Square. Then it occurred to him that perhaps he should say a prayer, so he did.

“I’ve got Ethel on the phone,” called Huma. “I figured you’d want to talk to her.”

“Yes, thanks, Huma. Tell her to come over right away, please.” His voice broke again. The bastards were getting to him! How dare they attack a person in retaliation for an idea!

Jacquie came back in carrying her tablet. “Paul’s on the way; he’s texting her. Take a look.” She put her tablet down on the desk and pushed an icon. It showed the front half of the house engulfed in fierce flames with a vehicle looking like a golf cart sticking out of the garage.

“What’s that?” asked Will.

“A personal transporter like the ones we have up here. Apparently it was programmed to drive right up the driveway and into the garage, but it exploded when it hit the door.”

“What time is it there?” He looked at the news feed; it had the time on the bottom. “Ten thirty-four a.m. She’s usually walking in the mall at this time.”

“Let’s hope she followed her routine!”

“But it’s such a beautiful house! I grew up there, mom lived in until she had to move to a nursing home . . . it’s so terrible.”

“It is. But it isn’t the place it was when you grew up anyway, Will. All the trees are gone, thanks to that cold winter two years ago. Stamford is devastated. The memories are better.”

“True, but this is terrible.”

Paul hurried in, then Ethel, and they huddled together watching the screen. Huma came in and made everyone coffee. Will glanced at the time; Mars and Earth were 110 million kilometers apart, or about 330 light minutes, so round trip communications were

660 minutes or 11 minutes. Then Paul's communicator beeped. It was Molly. "Paul, what are you saying? My house? I'm at the mall right now. I'd better call the police and find out whether I can go home."

Paul immediately hit reply. "Mom, someone may be out to kill you, so call the police right away and find out what they advise! Better; the mall has a police station, please go there right away!"

"We're all here, worried!" added Will. They all stuck their heads into the camera's viewing area so she could see all four of them.

"Please assure us you're safe!" added Jacaranda. Then Paul closed the call.

"Here it is!" shouted Huma from the other room. "The New York Times says they've received a call from a man saying that the White American Christian Militia firebombed Molly Nuri's house because her brother was a traitor to America and a danger to the country's future."

"WACM," said Will. "They're probably behind the cyber attacks, too. I hope the FBI can 'whack 'um.'"

"Meanwhile, they've been doing a lot of whacking," said Jacaranda.

"What's mom going to do?" asked Paul. "We're her entire family, and we're here! Her house is destroyed, she'll have to sort through the mess herself, get another house, and the police may want her in protective custody . . ." Paul shook his head and tears came to his eyes.

"And it's too late for us to go there; there won't be another flight for almost two years," said Jacaranda. "She has a good support system, though. The Bahá'ís of Stamford are great."

“Did she have insurance on the house?” asked Ethel.

Paul shook his head. “I don’t think so. Three insurance companies in a row went bankrupt on her.”

“Over half the houses in the U.S. are uninsured at the moment,” noted Will.

“Oh, I wish I had never come here!” exclaimed Paul.

“I feel this is my fault, too,” said Will.

“Well, she would have agreed with every word you said,” replied Ethel. “So would have your mother. This is a situation not that different from that of the Bahá’ís of Iran. Their property is being destroyed because of their beliefs, and some are still being murdered, in spite of Iran’s democratic government.”

“That’s a good point,” said Will. Even Jacaranda, who had lost her belief some years earlier, nodded.

“Is it time for a public statement?” asked Jacquie.

Will nodded. “I think so, though let’s not mention WACM; the claim might be false, and I won’t dignify them by mentioning their name anyway.”

Nothing else got done that sol. Will made a statement condemning the attack; President Mennea offered a similar condemnation and pledged the full force of the FBI would be brought to bear; Paul issued a statement; even Marshall, on Titan, was asked for a statement and offered one. Molly rented a room at a very expensive hotel where a policeman was stationed outside her door. It was late at night at Aurorae but early evening in Connecticut when Will, Ethel, Paul, and Jacaranda sat on a couch in front of a

large screen in Will and Ethel's living room and opened a live line with Molly. Paul and Jacaranda's nine year old twins stood behind the couch and participated as well.

"I'm beginning to come out of the shock and surprise, at least," said Molly when she opened her end of the line. "I just got back from the house. There's not much left standing. It's a total loss, and no, it had no insurance. The police said they'd give me a guard for a month, but that's all. I've checked with my friends in Cochabamba, and I can go to Bolivia to stay with them for a few months. But before I get a plane ticket, I have to buy everything I'll need; a suitcase, clothes, shoes, even a tooth brush! The hotel gave me a toiletry kit, but it's pretty cheap. All our pictures are gone, all the mementoes, everything. I've already had calls from several companies offering to remove the debris. It's . . . well, it's overwhelming. I'll send this to you and go find a tissue." Her voice broke at the end, and that gave everyone on Mars lumps in their throats.

"Say, Molly, there's one possibility Ethel and I have been talking about," said Will. "You could come here. There are still two shuttles heading to orbit with passengers, and there's a very good chance we can get you on one of them. The galleon *Isidis* departs for Mars in ten days; it's the last vehicle this columbiad, and it's coming the fastest. I'm sure we can get you accommodations on it. I can ask that they use one of my free flights to accommodate you. All of us get one free round trip flight to Earth after nine columbiads and I am owed two, at this point! There's plenty of space for you up here, in our house for a while, but we can get you a place of your own as well. You'd have two grand children to be with and my two grand kids as well. Ethel and I will be retiring in a few years and we'd all be able to spend time together."

"We'd love to see you, grandma!" added Tracy.

“What would she do?” asked Paul. “I know, mom will be thinking that as soon as she hears this!”

“A lot,” replied Will. “We need more people here who don’t have specialized training. As a retiree she can volunteer anywhere she wants; day care, the schools, the hospitals, the museum, the arts center . . . you name it.”

“She’d enjoy the museum, and they can never hire docents,” said Jacaranda.

“Of course, they’re almost never open, either, because no one goes,” said Paul.

“But the arts center is pretty active.”

“Her pension won’t go far, but we can finesse that one,” added Will.

“Will people accuse you of favoritism?” asked Paul.

“No,” replied Will. “Last columbiad when immigration was large and very disorganized, we added parents, grandparents, uncles, aunts, and children to the roster at the last minute. We couldn’t fill the launch berths because of all the disruption to the transportation systems.”

“This would be an emergency, too,” added Jacaranda.

“I suppose they can handle all the necessary training on board the *Isidis*, too,” said Ethel.

They continued brainstorming until Molly’s responses came back. “Come to Mars?” said Molly, when she heard the first comment. “That’s radical! . . . Ten days isn’t much time to get ready, do you really think it’d be possible? . . . I really don’t want to be a burden or be dependent on someone else . . . Yes, dear, I’d love to see you and Samantha, too . . . volunteer work, huh? The museum . . . the arts center . . . interesting idea . . . but I don’t want to be a burden, financially, you know how independent I am,

just like mom was . . . well, that's an interesting idea . . . I must say that I would like to go to Mars some time, but not under these circumstances."

"This is as good a time as any, mom," said Paul, knowing she wouldn't hear him for eleven minutes. "And I wouldn't wait; you'll be 73 this year! They'll want to make sure your heart can handle three gees."

"We really would love to have you," said Jacaranda. "The kids would love to have you around. So would their friends; this place doesn't have very many grandparents! You could practically be a professional grandmother here. I suppose that doesn't sound too appealing, but there are a lot of people up here who could use your love. I'm not talking about baby sitting, but all your knowledge, love, experience, and personal qualities you could share."

"I suppose I should think about this very seriously," continued Molly, thinking aloud to fill the time. "It'd be a new start, that's for sure!"

"Molly, don't worry about being independent," said Will. "Ethel and I have an entire extra apartment in our house and it'd be easy to invest in a condo here. You'd have your own place. I think the Commonwealth has extended pensions to other relatives of residents, though we'd have to check into that, and many of the volunteer positions we mentioned could be paying positions as well. This is a small, informal place and people find ways to accommodate each other. I think this could work out quite well."

"It'd be good to bring the whole family together in one place," added Paul.

"Do you really think this could work?" asked Molly, continuing to muse about the idea while their comments flew to her at the speed of light. "There's not much keeping me here; the house is gone! But I'd have to get to West Texas spaceport pretty quickly. I

don't even know what clothes I'd buy, or what I'd put them in for the flight! This crazy idea sounds more and more interesting!"

All of Ceres watched the descent of the *Wolf* from orbit, into which it had briefly inserted itself, to the surface. The level of excitement at the thought that twenty-three more people were coming to Ceres was palpable; even the adults were thrilled. When the *Wolf* touched down one hundred meters away from the *Piazz*, they all cheered. Then it activated its vernier engines and took off under very low power. Hovering 1 meter above the surface, it slowly moved closer to the *Piazz* until it was just forty meters away, when it landed again. Ken Leonard and Jack Alberghini were outside waiting and approached, dragging an inflatable tunnel behind them. Suited personnel on board the *Wolf* lowered the airlock extension to the ground, descended, and helped Ken and Jack attach the tunnel. They secured it, tested it, and began to inflate it. A mere hour after touchdown the crew of the *Wolf* began to exit into a shirtsleeve environment and half walk, half float the forty meters to the *Piazz*. Helmut was there at the base of the ship to greet them.

"Welcome to Ceres!" he said to Umberto Ross, the commander of the Jupiter-Trojan mission. "I can't begin to tell you how delighted we are to have you with us for five months!"

"And we're delighted to be here!" added Ross, shaking his hand. "You are now our Commander and we are at your service, Dr. Langlais!"

"Thank you. Ceres goes from sixty adults and twelve children to eighty-three adults and twelve children, unless you count my son as an adult."

"I understand he's eighteen and accompanying us to Lutetia, then on to Mars."

“And he has read every article about Lutetia published in the last century, so watch out! As requested, I’m granting one month of shore leave to all your crew, so you can enjoy the greenery and the Cererean volleyball. We hope some will stay, too.”

“I think six or eight will, and I gather four of your crew are coming back to Mars with us.”

“Those are the current numbers. Others are awaiting the regular rotation in 2075. It’s a shame you won’t stay, too!”

“No, the *Wolf’s* my baby. Besides, I suspect I will be back in 2077. It sounds like your proposal for exploration of the Asteroid Belt via Ceres has been dusted off and put back on the table.”

Helmut nodded. “I think so. Even the Jupiter Trojans are quicker to reach from here than from Mars; it’s a one-year flight instead of two. Let everyone stop here on their way to asteroids and Jupiter Trojans. We didn’t name this place ‘Central’ for nothing.”

Umberto Ross laughed. Helmut pointed to the entrance to the *Piazzi*. “Go right up the ladder and into elevator 2, which will take you to the great room on the third floor. We’ve moved back all the retractable walls and added the classrooms and briefing room to the great room. We’re cooking every specialty we have here, and we’ve pulled out the wine as well! We’re going to give you guys a welcome like you’ve never had before!”

“I’m sorry for the delay in this cabinet meeting,” Will began, ten sols after the Nobel Prize ceremony. “It’s been a hectic, even crazy, time.”

“But your sister’s on the way, right?” asked Alexandra, who had been invited to attend the meeting.

“Yes. That was an emotionally draining crisis; it didn’t take much time, but left one feeling unable to do anything! Fortunately, there was a young Lebanese woman—a plant geneticist coming here to help genetically engineer low-light crops—who is a Bahá’í and who became an immediate traveling companion for Molly. So she’s in good hands. The last minute turmoil over the last two launches because of terrorist threats; that took time and energy, too.”

“But now everyone’s on the way,” said Yevgeny. “The last cargo coming via chemical propulsion left in October; 1,200 tonnes of it. We have 2,400 tonnes to launch and fly here via solar sailers and solar thermal engines and that effort starts next week.”

“At a much lower price per kilo,” added Hun-jai. “Because of the long-term interest-free loans we gave the Brazilians, Kenyans and Indians to repair their spaceports, they’re giving us the pre-war launch price, so everyone else has to follow suit.”

“How did we manage to order 3,600 tonnes of stuff?” asked Henry. “I thought this crisis was supposed to make us more self sufficient, not less!”

“Well, businesses have ordered 700 tonnes of equipment and machinery,” replied Hun-jai. “That effort was pretty successful. Half of it goes into orbit in the next two months and will be launched with a solar thermal engine to Mars via Mercury, arriving in October and November next year.”

“Half our caravels go back to Earth via Mercury and half via Venus,” said Yevgeny. “And the Venus Commission wants one of our caravels to accompany their caravel next December to Venus because when it arrives there’s a near-perfect trajectory on to Mars, arriving here twelve months after leaving Earth. It’s a long flight, but would get 100 people here at least six months before the next big wave of immigration.”

“The nineteenth columbiad,” agreed Will. “That’s my main concern for this meeting. We’re flying a bit over 1,000 new folks here on the eighteenth columbiad, fewer than flew here in the seventeenth and even the sixteenth columbiad. We’ve had a rest here, but there’s plenty of time to prepare for a really big wave, especially since Ramesh has cut the cost of enclosures by a third and the construction folks have cut the cost of housing that much as well. We can house and feed people more cheaply than ever, we can fly them here more cheaply than ever, and we can import their machinery more cheaply than ever. Mars will soon have 11,500 people; by 2074 we’ll have 12,000. Could we handle 4,000 immigrants that year?”

“You want to go from 1,000 this columbiad to 4,000 the next?” asked Yevgeny, surprised.

Will nodded patiently. “It’s possible, especially if we use all our launch windows: via Mercury, via Venus, and direct. As I said, enclosures and housing are cheaper than ever. Our construction companies are actually hurting because of the small size of the current expansion; give them an extra six months by announcing our plan now, and give them loans, and they’d be ready. The Prometheus will make launches to low Earth orbit cheaper than ever, and even if it is delayed, the existing shuttle fleet can handle the 60 or 70 launches that would be necessary. The moon’s hurting; a big fuel contract would help it a lot. Phobos wants to crank up galleon production and if they built two more in the next two years, they’d be going at full production. There’s still time to order parts and get them here next fall via Mercury. We’d need two more gaseous core nukes; that’d help Phobos and Deimos. That would break in two more galleons, which I think could be sold to the Jupiter, Saturn, or Asteroid Commission. The Lufthansa safety report suggests that

caravels can indeed accommodate more passengers. I wouldn't go to twenty cubic meters per person, but thirty should work with inflatable zero-gee facilities. Even if we left two caravels in Earth orbit that are there now and just flew six here again, they'd accommodate 250 each, and three galleons could accommodate 750 each; that's 3,850 people."

"If the caravels of the Mercury and Venus Commissions are included, we could probably fly another 300 here, so that would indeed reach 4,000," said Yevgeny. "We can negotiate with the Venus Commission to plan a faster trajectory, leaving Earth in February 2073, flying by Venus in June, and arriving here in November; soon enough to return to Earth during that opposition."

"They'd like that. So would Lufthansa, United Spaceways, and the Green World Community's caravels. What about Mercury?"

"The launch window from Earth to Mercury to Mars opens seven months before opposition between Earth and Mars, plus or minus about a month and a half," replied Yevgeny. "It's close to a Hohmann trajectory each way and takes about eight and a half months, so the vehicles reach Mars about a month and a half after opposition on average."

"The safety people will be breathing down our necks," warned Jacquie Collins.

"Not necessarily," replied Will. "This will require careful planning, but if we want to continue increasing immigration, we have to use all the available launch windows. The vehicles will fly in convoys to provide each other lifeboat capacity. We've flown pairs before, but there are proposals for docking three or even four vehicles together during

interplanetary cruise, which gives people more radiation protection and more spaces to amble through. We'd want to be sure to fly extra oxygen, water, and food."

"What would you say to critics who complain you want to end your last term with a bang?" asked Lal.

That surprised Will. He peered at the Chair of the Mars Council. "First, who says this is my last term? I'm not committing myself one way or another. And second, this is about Mars, not me. We have to grow to become great." He said the last rather emphatically.

"Four thousand people means we'd need at least 500,000 square meters of polder," noted Emily Scoville-Rahmani, tugging on her hijab nervously. "That's a lot; the Caribbean enclosure Ramesh has started is 210,000 and is supporting the current migration. An expansion for 4,000 would require a half million tonnes of water, 1,500 tonnes of oxygen, and 1,000 tonnes of nitrogen-argon mix. I don't know how many tonnes of compost and fertilizer it'd need; maybe 2,000 tonnes."

"You forgot the thousands of tonnes of nickel-steel pylons and airtight skirting, the thousand tonnes or so of Kevlar cables and netting, the five hundred tonnes of dome material, plus the fans and pumps," said Will. "Big numbers, but possible. I know the capacities of our factories. The bigger issue is how many enclosures to build, and where; everyone but Aurorae wants Aurorae to grow more slowly, but we can't build an enclosure at every single outpost. It takes too long to move the equipment around and set it up, and it's expensive to haul the materials from the factories here to the other outposts."

“If we bring 4,000 immigrants here in 2074, how many will we bring in 2076? Six thousand?” asked Henry. “And how will we employ them all, because right now I project there may be a thousand private sector jobs making consumer goods.”

“I bet it’s less than a thousand, Henry, because of automation,” replied Will. “No, I’d focus them on solar system exploration, if I were chief minister in four years. Think about it. We can build one galleon per year with about a thousand workers and with some imported parts. Send that galleon to Uranus, Neptune, Saturn; name the destination, it really doesn’t matter. We can’t support that galleon practically at all if it gets in trouble; it’s too far away. But we will always send two galleons and lots of supplies, and the 300 or so people on that voyage will largely take care of themselves. The nominal mission, round trip, is ten to twelve years; at the end of that time the vehicles need to come back here or to Earth for a major overhaul and the personnel probably want to do something else with their lives anyway. How much ground support do they need? A couple dozen people to invest their pensions, a few doctors to consult with their medical personnel, and a lot of engineers on call to advise if there’s an emergency. If Mars has 15,000 to 20,000 people, it can easily keep 1,000 employed supporting all the other bases in the solar system, making things for them and helping them with problems. Maybe there will be a thousand on Earth as well; that’s fine. But consider where it puts us. Three hundred people aren’t enough to be fully autonomous, so none of these bases will be independent nations; not for many decades at least. They will be communities that look to Mars for advice and support. People will go there from here; they’ll return here; they’ll go out to another place from here. Who says all roads have to lead to Earth?”

“Mars will lead humanity to the stars,” said Jackie Collins, quoting Will.

“Exactly,” he replied. “We really will, because we will make it a priority. We won’t argue whether people should go or not; we’ll send them. And we won’t devote half our economy to military spending and retirees. Not if we keep growing.”

There was silence in the cabinet meeting for a moment. “Four thousand is possible,” agreed Yevgeny.

“Then let’s make a plan,” exclaimed Will.

Hard Place to Love

Early February, 2072

Ambassador Zhao Tao rarely wanted to meet with Chief Minister Will, and when he did, he usually wanted something. Will checked his database and had the ambassador's coffee ready, with milk and two lumps of sugar on the side.

"Dr. Ambassador Tao, it's good to see you again," he said, rising from behind his desk as the ambassador entered. The ambassador had agreed to the use of his first name with the title "ambassador" but wanted "Dr." added to it as well.

"It's good to see you again also, Chief Minister Will." They met near the middle of the room and shook hands. Will pointed the ambassador to the table; he sat, and Will brought him his coffee.

"As you like it."

"Thank you so much. So, how are you doing? Relieved everything is going smoothly, for once?"

"Yes indeed, the last two months have almost been boring! I've actually been able to get a decent sleep. I trust your courses at Martech have gone well."

"Reasonably well; without immigration, there aren't many students for Chinese classes. When the arrivals start to land in mid March, everything will start hopping, and the summer language courses will probably fill up. I think everyone has appreciated the lull, but it has made some aspects of this place slow."

“That’s one reason I favor a steady level of immigration; it keeps everyone busy and keeps everything expanding.”

“Indeed; it certainly keeps down the level of boredom! In fact, that’s the main reason I asked to speak to you, Chief Minister Will. My government was rather surprised by the plan to bring 4,000 here in two years. The growth rate of Mars has been slowing, but now it has lurched upward dramatically. It makes us wonder how much higher it can go.”

Will shrugged. “I suppose from four thousand it can go to six, from six to nine, from nine to thirteen, from thirteen to seventeen . . . when Henry Hudson arrived in New York harbor in 1609 with a few dozen men, could he have imagined huge steel steam vessels arriving with thousands of immigrants, three hundred years later?”

Tao chuckled. “But this is much less than three hundred years. When you came to Earth in 2059—just thirteen years ago—you challenged the various nations to send 7,000 people to Mars in ten years. Immigration was about 400 per columbiad. Now it’ll be ten times as much. In another thirteen years, will it be 40,000?”

“Maybe more; we were delayed by a war, after all. This is not hard to imagine. Shuttles to take people to low Earth orbit started with seven passengers; they now can carry 75; the Prometheus will transport 150. Low Earth orbit tourism has transported as many as 3,500 per year to space. In ten years one can imagine a vehicle capable of launching several hundred at once, maybe more. The first transportation system brought 6 to Mars; a galleon on a three-month trajectory can carry 750 and if we ever build a Galleon II, which has been on the drawing boards for several years, it would be able to

transport 1,500. I can imagine ships capable of bringing 10,000, can't you? But I get the feeling this debate is not about the technology."

"You are correct, we are not debating technology here. Frankly, my government was surprised and not pleased by your plans for the nineteenth columbiad. We had assumed that immigration would get up to 1,500 or perhaps 2,000 per columbiad and stay there indefinitely. Your Park report proposed something like that a decade earlier. The prospect of a rapidly growing Mars—a Mars that grows exponentially for a century—was not something we expected."

"The Park Report predicted limits to our growth, but several factors intervened. First, gold prices appear to be up permanently. Even if they drop this year and next, as appears likely, they will still be up fifty percent over the prewar high. Second, launch and flight costs continue downward; every time a space vehicle doubles in size, prices fall at least fifty percent. Robotic technology is revolutionizing manufacturing of everything from rocket engines to H-75 bubbles."

"I know. Over the last four years Mars has imported the equipment to mine aluminum and lithium ores and extract the metals; to make aluminum-lithium alloys, machine the parts, and use friction welding to weld tanks; to manufacture rocket engines of various sizes; to produce and store large quantities of hydrogen and oxygen propellant. Consequently, you have the ability to manufacture your own shuttles, excluding the electronics, of course, but they are a small fraction of the total mass and easily imported. You can make large inflatable structures, so you can make the hulls of galleons. You've imported the equipment to produce large carbon fiber structures, making shuttles, galleons, and caravels lighter and stronger. You've had the ability to apply thermal

protection to structures well over a decade. And with the war, you've acquired nuclear fuel production, reactor production, and gaseous core engine production. With the Prometheus project, in close cooperation with Russian engineers, you've acquired a lot of advanced rocket technology, and the experience to make shuttles on Earth as well as Mars. Now, my government realizes that Mars has the population to use these technologies as well! That is the surprise to us, Chief Minister Will."

"I suppose it comes as quite a shock, then. But you are quite right; galleons require about a thousand workers, rocket engines and shuttles will require another thousand if we start producing them here, gaseous core engines and associated fuel production need another thousand, plus there are synergies the three bring to each other. With a total work force of nine thousand workers such as we will have in a few months, three thousand is a rather large commitment; but when we reach thirteen thousand workers, or sixteen thousand by 2076, the commitment will not be as extreme. However, three thousand workers equals only a billion redbacks per year of economic resources, which is nothing compared to what the United States, China, even India and Brazil have been devoting."

"That's true, Mr. Chief Minister." Tao leaned closely. "But as you know, our space programs, historically, have not been very efficient. You can accomplish as much with a billion redbacks as we can with five or even ten billion." He shrugged.

"That's not our fault, Mr. Ambassador, that has to do with politics! Furthermore, we are not trying to shut anyone out. Have we not repeatedly said we want partnerships? Have we not repeatedly called for collaboration in space?"

“You have, but the Chinese government now realizes that flying some Chinese Marsians to Jupiter is not necessarily the same thing as flying Chinese there!”

“Let’s not forget that the Chinese Marsians included a Nobel Prize winner, and he is now living back in Beijing, probably permanently. Chinese come here, they go to Jupiter, they go back to China, they come here again, they go to Venus, they go back to China . . . it is not a simple one way flow of personnel. There are Marsian born kids here, half Chinese or full Chinese or not Chinese at all, who may be professors in your universities in the future, who may be serving in your space bases and employed by your astronaut corps. The ‘Chinese’ man who won the Olympic gold medal in the 1,000 meter race in the last Olympic games was from Sri Lanka, and I understand he spoke excellent Mandarin! This is the wave of the future. We are committed to building a multiracial, multinational, multiethnic, multilingual Mars and dedicating its resources to exploration of space. That’s what we are doing. It’s not a secret, either. We want more Chinese here.”

“Well, I don’t think you can expect a Chinese subsidy for immigration any more.”

“Perhaps not, but we haven’t asked *anyone* for subsidies any more. Americans, Europeans, Indians, Latin Americans, Africans . . . 4,000 immigrants in 2074 may very well cost us half as much as 1,000 this columbiad.”

“Launch prices shot up after the war ended, and now they are dropping again.” Tao picked up his coffee cup and drained the last gulp from it. He rose. “Thank you, Mr. Chief Minister, for the conversation. My government wanted me to ask for clarifications about your plans and policies, and I have.”

“The plans and policies already were clear, but have I clarified things sufficiently?”

Tao nodded. “Yes. I appreciate your time, Chief Minister Will, and I look forward to many more conversations, and I hope more collaboration.”

“Excellent. Ciao, Mr. Ambassador.”

“Ciao.” Tao shook hands with Will and walked out of his office. Will sat behind his desk and contemplated the meeting. Huma came in.

“Shall I send the transcript to Pete?”

“Yes, and Pete should go to Beijing for further conversations.”

“So, do you think China just realized we were a real threat?”

“I think they suddenly have realized we’re a major player and they have to take us seriously,” said Will, nodding.

“Maybe you should talk to Enlai, too.”

“Maybe I will.” He thought. “I think I’ll call Charles Vickers first, though. Thanks, Huma.” Will pulled his tablet close to him and set it up in a stand. Charles’s number popped up on command and he began to tape. “Good sol, Charles. Haven’t heard from you for several months, which I suppose means the cargo flight and the caravel have solved your problems. I’ve followed the mission to Themisto with considerable interest. We’re looking forward to seeing you back here in 2074.

“I wanted to ask you how relations are going on Callisto between the Chinese and the American-Marsian teams. I just had the strangest visit from the Chinese ambassador. It would seem the Chinese government just did the math—they could have done it years ago, but they didn’t—and realized that in another columbiad or so, Mars will have the minimum population to build caravels, galleons, shuttles of various sorts, and gas core nuclear engines, and therefore Mars will be in the position to shape the exploration of the

entire solar system. Note I didn't say 'dominate' but I think that's what China concluded when they did the math. I have a bad feeling something is coming our way. The visit appeared to be just a probing conversation—'so, are you really planning to become a major player?'—there were no threats. Callisto is the biggest Chinese operation by far, so I am wondering whether you have any insights into their thinking. Thanks, Charles, Bye."

He sent the videomail. Jupiter was close to a billion kilometers away that sol, so round trip communications would take nearly two hours, assuming Charles responded right away. So Will went to the Gallerie for lunch, then to Martech for a meeting of geologists to discuss a mission planned for the Thaumasia Highlands. When he returned, Charles had responded.

"It's good to hear from you, Will. Yes, all is going well here. The departure two years ago of the Brazilian caravel *Pedro Álvares Cabral* and quite a few personnel from both teams—including Tang Enlai—was quite a blow. Morale was low and that exacerbated tensions between the two teams. Since neither of the remaining caravels could leave Callisto because they had been reoriented for Callistian gravity, and because neither team wanted to move in with the other, we had no inter-satellite transportation. Of course, there aren't many manned missions you can mount here with Io, Europa, and Ganymede in the middle of the jovian Van Allen Belts. Three of the solar system's most interesting worlds, and they have to be explored remotely! But we did what we could and we did receive several robotic sample recovery flights. We are immensely grateful for the caravel *Sagittarius* you sent, and since its arrival everyone's feeling much better. The Themisto mission had been repeatedly postponed and we are glad to have it underway.

We hope to visit Himalia as well before the *Sagittarius* departs for Mars in about two years. Yes, Martha and I will be on it. We'll have spent almost a decade on this mission, we'll both be in our early sixties, and Caitlin is getting married soon, so we anticipate a lighter workload, opportunities to advocate for Jupiter, and family time.

“The situation here seems stable enough and ‘the Yugoslav system’ of co-commanders seems to be working well enough, though it requires a lot of talking. The arrival of the *Sagittarius* disturbed the balance somewhat in that China was unable to support the mission at all, so the crew here feel that Mars is now dominant. I was the commander with veto power, too, so maybe that made it worse. My counterpart has veto power as of January 1, though, and over the last month things have felt better.

“As for ‘doing the math’: Maybe you and a group of Mars enthusiasts have been doing the math for years, but the announcement that Mars would import 4,000 migrants in 2074 has everyone else doing the math as well. Everyone knew about galleon and caravel construction, which gives Phobos dominance over interplanetary spacecraft construction. Everyone knew that Mars now had the capacity to make gaseous core engines and enriched uranium reactors thanks to the ‘Mars-American war.’ Everyone knew you had been beefing up shuttle construction and had been pouring money into the Prometheus project. But importing 5,000 workers over two columbiads when all those projects require about 3,000; that’s simple math, Will! I was shocked. I am sure people are wondering how many will be imported in 2076, in the next decade, how many people will Mars have in 2100; clearly if the trend continues, Mars will still be a tiny nation compared to most nations on Earth, but it will dominate space, and space is the ‘high

ground.’ It’s also prestigious. Either you are forcing the other nations to compete against Mars or to pull Mars down.

“I may have inadvertently contributed to the situation. Commander Chen and I had a long conversation over New Years about the future of jovian exploration and I constantly mentioned capacities Mars had or soon would have. I think the Chinese government has been postponing all his requests, too. This is a hard place to love and it will be viable only if it has at least two galleons, like Saturn, and a crew of 300 to 500. Right now our community is too small; the children all have to leave for college educations, mates, and careers. People even worry about the high school education available to them. Most of us don’t think the arts are all that important, but we don’t have practically any, and we do miss it. Promotional possibilities are limited. We need two very heavily shielded caravels so that crews can go to Ganymede; there are spots where the radiation environment isn’t too bad, and there are still things people can do that robots and remote manipulation can’t. Both moons also need infrastructure; reactors, propellant manufacturing, fuel tanks, covered shelters, and special shielded surface vehicles. Mars’s policy of perpetual immigration and growth was essential for its development. We can’t do that, but if we can get our population up to several hundred—a thousand would be even better—with rotation of a hundred or two every other year, we’d have a viable community and enormous exploration capacity. I think that vision startled Chen because he knew China wouldn’t do that, not in the next decade or two anyway.

“Well, I’m rambling. Looking forward to seeing you in about three years! I hope that helps. Bye.”

Will immediately hit the reply icon. “Thanks, Charles, I think that’s very helpful. We’ve been pushing the Jupiter Commission for months to commit to the purchase of two galleons and have even said privately we’d donate one of them. Both China and America have been resisting, and maybe now I know why. They’re probably wondering whether we’d send a galleon or two all by ourselves! We’ll have to think about this situation. Maybe we will encounter outright opposition. Let’s keep in touch. Bye.”

Will sent the message and looked up; Huma had heard him conclude the conversation and had entered his office.

“Will, there was just a terrorist attack against the White House,” she said. “A small drone with explosives was flown into the Oval Office, where it detonated and destroyed the office. Part of the White House is on fire. The President was in a cabinet meeting at the time, but his secretary was killed.”

“Oh my God.” Will shook his head sadly. “Has anyone taken responsibility?”

“WACM.” She pronounced it “whack-um.”

“The FBI has to get them. This is terrible. Where’s Jackie? She needs to work on a statement.”

“She’s home this sol. I’ll call her. You want to videomail the President, I’m sure.”

“Yes, I’ll do that right now. I’m glad he’s alright. Thanks.” Huma stepped back out; Will pulled up the BBC and watched the live coverage for a few minutes while he got over the shock and digested the situation. Then he pulled his tablet close and opened a video message. “Mr. President, I am shocked and saddened by this attempt on your life. But I’m sure you understand this is happening because you are doing something that is right, something the irrational forces of reaction cannot accept. America will lead the

world through the mechanism of the Grand Union; what other country has the diversity, the resources, and the political and social systems to do it? And you are the man who will put the vision in place. You will go down in history for your bold leadership. This terrible act cannot reverse the flow of history; it can only strengthen it. I'm proud to be your friend and stand ready to assist." He stopped the recording, uncertain what else to add, then on reflection, sent the message.

"I wonder what will come from this meeting," Marshall said to Amy as they entered Titan's Great Room on the second floor of N-4. They were among the last to arrive, so the tables were mostly full, but Soo and Guangya Kwok waved; they had saved space at their table for the Elliotts. Marshall was carrying Willie; Yam-kuen was in the only high chair, so he put the baby on his lap.

"So, are you staying or leaving?" Guanya asked Marshall.

"Why would we be leaving?" Marshall replied.

"The bigger question is, how long will we stay?" said Amy. "Willie will be in kindergarten in three years. I could see staying until he finishes sixth grade, but after that. . ."

Marshall frowned. "There are a lot more kids here than when I was growing up! My high school graduating class had two, and I did fine!"

"But they won't all stay," said Guangya.

"And I'm not sure I want to be doing the same geology in six or eight years that I'm doing now," added Soo.

“What do you mean?” asked Marshall. “Titan’s almost as big as Mars, which is much better studied. There, you’ll be going down old trails trying to find new side trips. We have an entire world to explore here, not to mention all the middle-sized moons that we have just begun to characterize.”

“The geology’s at least as good as Mars’s, though it’s harder to access,” she conceded.

“And Mars is doing some really interesting stuff with ecology now,” noted Guangya. “Our work will settle into a routine.”

“Why?” asked Marshall. “The push on Mars to increase the polder to 150 square meters per person has produced some interesting new crop combinations, and they need to be tried here, too.”

“The cargo flight on the way has seeds for fifty new species,” agreed Amy.

“And why can’t you do original research here?” added Marshall. “You’ve got the illuminated area and the equipment. I’d make an argument to the Saturn Commission that ecology professionals here need the same opportunities they’d have anywhere else.”

“We are being treated like farmers,” said Amy. “Promotional opportunities are limited here.”

“Depends on the turnover rate,” said Soo.

Just then Yuri rose and walked to the front. Behind him was a screen showing the crew of the Phoebe expedition; thirty-five members, crowded into the great room of the *Victoria*. “Let’s get started,” he said. “Over the last two months, there has been quite a debate going on informally about staying versus leaving. On Friday, we will need a

preliminary count of who plans to leave; that will help determine the roster of the Saturn 2 flight. The *Cassini* leaves Mars in two months.”

“Yuri, let’s say 100 of us decided to leave,” said Gandhimohan. “Does that mean the *Cassini* will come with only 100?”

“No, it’ll come with 150 unless less than 50 want to head back to Mars. We are getting another reactor and a lot of equipment for generating hydrothermal and wind power, but safety margins on our galleons are such that we can’t grow our population by more than about one hundred adults.”

“What about here underground?” asked Ryoko.

“We have plenty of margin here,” replied Sridhar, who was in charge of base construction. “We’ve cleared twelve tunnels and inflated all twelve of the bubbles we have, but four of the spaces are just big, empty, cold oxygenated volumes, and we have no plans to use them right now. The eight we are using all have parks that are more or less complete, plus at least one horticultural level and at least one completed level for work space. We have 50,000 square meters of horticulture, including the parks, and 20,000 meters of work space; more than we need, and all eight bubbles can accommodate two or three additional stories, depending on the configuration. If we completed the other levels and filled the other four bubbles, they could handle a population of 750 maybe 1,000.”

“Lots of redundancy,” concluded Yuri. “But everyone needs gravitied space for their health, and we don’t have enough of that. Now, I don’t want to get into a debate about whether people should stay or leave. That debate has been raging informally already and I don’t think a public discussion will add much. Instead, I want to ask

everyone how we want to set up ownership of our gravitied apartments and of the cottages we plan to build in the eight park spaces. A related matter is ownership of businesses; we have a 'company store' right now that could be privatized, and several people have private weekend businesses cutting hair and providing other services that could operate in spaces here in N-4. Sridhar, do you want to elaborate?"

"Sure." Sridhar rose. "There are two ownership models we are considering: direct and indirect. In the direct model, you buy your apartment or cottage and pay mortgage payments, which would include interest, plus a condo fee. If you decide to leave, you either sell it back to the Commission or privately to an arrival. In the indirect model, we set up a condominium association that owns the structures. You'd pay a monthly condominium fee to cover expenses plus rent roughly equal to half the monthly mortgage payment, which would cover construction costs over a twenty or thirty year period. You'd have the same privileges either way; painting the places, changing the rugs, even subdividing or joining rooms. The condo setup will cost you less, so you will be able to save and invest elsewhere. The ownership setup will cost you more but you'll get it back when you sell the place."

"And we'll be guaranteed a sale to the Commission?" asked Toru Takahashi.

"Yes, at the purchase price."

"So, if we invest elsewhere, we'll probably make more return?" asked Rahula Peres.

"Real estate here isn't going to go anywhere," replied Sridhar, with a grin. "I think we can be sure of that! But investments are unpredictable, too."

“I guess the other factor is a psychological one: do we want ownership of something here,” said Marshall. “Even if the housing spaces are easy to sell, that’s something to consider. When we first introduced ownership on Mars, we didn’t give people condo options, and there were less than 100 of us.”

“Yes, but this isn’t Mars,” replied Sridhar. “We aren’t a five month flight from civilization. We’re a lot farther out, and in a much harsher environment.”

“One that tried to kill you twice, Marshall,” commented David Omar, a fellow geologist.

“And it didn’t get me either time!” replied Marshall, with a smile.

“As people have said before, this is a hard place to love,” commented Guangya. “I don’t have to go outside at all, so I don’t. On Mars, people go outside for fun on the weekend. They even play golf. But I don’t think we’ll have an Acheron Golf Club any time soon.”

People laughed at that. “You’d need a green glow-in-the-dark golf ball!” quipped Tomas Racan.

“I think it’d shatter when you hit it, anyway,” added Adel. “But that happens sometimes on Mars, too.”

“Let me ask for an informal survey,” said Yuri. “I apologize to the people on Phoebe because I can’t see you very well. How many people are thinking seriously about leaving in 2074?”

Everyone looked around and watched as hands began to go up. Yuri made a rough count, including people visible on the screen. “Looks like about sixty. How about 2076, 2078, 2080? Let me see for 2076?” He counted. “That’s about seventy-five. 2078?” A lot

of hands shot up, including Amy's. "Wow! That's well over a hundred. Who's left for after 2078?" He counted. "Twenty five; that's all? Marshall, looks like you'll be turning off the lights!"

Marshall laughed. "You all leave and others will come! This place needs at least 300, and they will come."

"They will, but they won't stay more than a decade or so, I think," said Yuri. "So, ownership versus condo: who wants to rent a condo?"

Two thirds of the people in the great hall raised their hands. Yuri looked disappointed; Sridhar had expected the result, so he didn't. "Okay, that helps a lot," he said. "We'll provide both options anyway."

"Thanks everyone," added Yuri.

7.

To Live is to Love

Late March, 2072

When Will saw the videomessage from President Mennea come into his inbox, he dropped his work to watch. He didn't hear from the President very often and regretted it.

“It's good to hear from you again, Mr. Chief Minister. Yes, we finally whack-emed WACM! I'm glad to hear the cyber attacks against Marsian communications have ended. You can assure your sister she would be safe if she returns to the United States. We very much regret that she and you were victimized by the group. But now that we have literally reconquered northern Idaho, that threat to the unity and peace of the country is history. The attack on your sister's house and the attack on the Oval Office caused many people who sympathized with them to desert their cause. It is always that way with extremism.

“It also means the American public is feeling more secure about the Grand Union; so the polls indicate, anyway. So the dark news is turning bright.

“I hope your fast has been going well. Allow me to wish you a joyous Naw-Rúz and best wishes for your new year. Bye.”

Will leaned back in his chair and played it again. Then he hit reply. “Thank you, Mr. President, for your best wishes. My fast has indeed been going well; I am now 70 years old and no longer need to abstain from food and drink during the day, so my fast is purely spiritual! I am delighted to see that support for you in the polls has gone up so much and the American public feels comfortable with economic integration with the

Grand Union. The Grand Union's decision to replace the geo with the 'world dollar' no doubt will help as well. I hope the terrible uncertainty and suffering is over for everyone. I hope this Lenten season is bringing you spiritual strength and Easter will be a renewal for you. Bye." He sent the message with a smile.

Huma came in. "Lenten season, huh? Is the President a practicing Catholic?"

"He was, fifty years ago. I suppose I won't hear from him again for a few months; there's no excuse to exchange messages. It is interesting that once he sent the army and the tanks into northern Idaho, the public rallied around him."

"He looked decisive. The right was cheering on the militia and the left was begging him to negotiate an end."

"And they were both wrong."

"Tree Rivers called a minute ago and asked to postpone his 11 a.m. appointment until morrowsol. He has some sort of emergency this sol. I gave him 2 p.m."

"Okay, that gives me more flexibility, if Molly wants to do something with me. He doesn't want to face me; he doesn't want to know how much I'll fine him!"

"How much?"

"I don't know, but stuffing an extra thirty people into their caravel and then having their folks hanging out in the *Isidis* sixteen hours a day deserves a big punishment! If there had been an emergency, people could have died. A million redbacks per person would not be excessive." Will glanced at the time on his tablet. "Well, I'd better get down to the square to meet Molly."

"The *Nirgal* made a perfect landing."

“I figured; no one reported trouble to me.” Will rose and headed out of his office, down the stairs, and out into Andalus Square.

It was 9 a.m. and the sun was pouring into the enclosure through a clear sky, the pink color rendered rather blue-purple by the dome’s tinting. Ethel, Paul, and Jacaranda were all waiting as well. They didn’t have long to wait; a minute after Will arrived, a Mobilhab drove out of the east tunnel and into the square with twenty-five passengers, the first third of the *Nirgal’s* load.

“There she is!” exclaimed Paul when his mother emerged, pulling a large suitcase. “Mom, over here!”

Molly dropped the suitcase and hurried forward—carefully in Martian gravity—and embraced him. “Paul, you’re a sight for sore eyes!”

“So are you, mom!” He choked up. “I wasn’t sure I’d ever see you again!”

“Me, too!” They separated enough to look at each other, then embraced again.

“Mom, you’re thin!”

“It was a rough trip, and then a long wait at Phobos.” Molly turned to her daughter in law. “Jackie, I’m so glad to see you!”

“Thanks, I’m really happy to see you as well. Welcome to Mars.”

“Thank you, dear. You didn’t bring the girls?”

“No, they’re in school.”

“Oh, of course. I can’t wait to see them.”

“And they can’t wait to meet their grandmother.”

Molly turned to her brother. “I can’t believe I’m here seeing you. I still don’t know what I think of it.”

“Welcome to Aurorae, sis,” replied Will, embracing his older sister.

“Thanks. It’s been quite a trip.”

“One you never imagined making.”

“One I’m still not sure I should have made! I’ll be useless here! I’m a fish out of water.”

“No, you won’t be; wait and see,” replied Will.

Molly turned to Ethel. “I am particularly looking forward to spending time with you. I know the rest of these guys, but we really haven’t had much time together.”

“We haven’t, and I look forward to it, too.” Ethel and Molly embraced.

“Well, you all have to retire so that you’ll have time to spend with me!” said Molly to the others. “Who’s carrying my suitcase?”

“I will,” Paul and Will both said at the same time, and both moved to grab the handle. Will deferred to Paul and he hefted it easily. “It’s a very short walk.”

“So I gather.”

Will pointed and led the way. They walked westward across the square and turned left at the Commonwealth Building.

“So, your office is in there?”

Will nodded and pointed. “Third floor corner office, next to the campanile.”

“It’s funny architecture; sort of like a Greek temple with a mosque minaret in Renaissance style attached!”

Will laughed. “You’re exactly right. You said the flight was rough; was it the crowding?”

“Partly. The Green Worlders were nice enough, but they seemed to be eating in our cafeteria all the time. They were friendly, but I hear they were sore losers in the zero-gee volleyball tournament. Actually, a lot of people seemed to like the four-way docking of vehicles. There were all these pressure tunnels snaking around that gave you a sense of what it was like to float in space without having to wear a suit. That was interesting; I went into either their tunnel or the tunnel to the *Ursa* almost every sol.” She sighed. “But the trip was rough on me because I really didn’t know whether it was a good idea. I usually like the challenge of the unknown, but this time . . .”

“You have lost some weight,” said Will.

“That’s because I really didn’t want to eat much.” She left that to hang in the air and no one spoke further about it.

They entered the southwest tunnel, which ran to the Bahá’í House of Worship, Half way down they stopped at a door and Will said “open,” which it did. They all trooped into the formal part of the house, a large living room that opened into a small private garden, with a kitchen on the far side.

“I’ll take your suitcase to your room,” said Paul, disappearing into the kitchen.

“Sit down and make yourselves at home,” said Will. “Let me get you some iced tea. I made it the way mom used to make it.”

“With a lot of lemon?” asked Molly, with a smile.

“Exactly. You and I can have some; the others are fasting, including Ethel, because she doesn’t turn seventy for a few more months.”

“Don’t rub it in, it’s not good for you spiritually,” said Ethel, with a smile.

“I suppose not.” He grabbed the pitcher and brought it out on a tray with glasses. Molly poured two, then a third for Jacaranda, who shook her head.

“No thanks. I’m fasting, too.”

“Oh?”

“Yes, I’m giving it a try, again. I’m coming back into the Bahá’í community, you see. I’ve been thinking about it a lot, lately, and praying a bit. I’ve decided I have to give my faith another try.”

Molly smiled. “That’s great, Jackie! You’re such a warm and loving person, I’m very happy to hear it.”

“Thanks.” She blushed a bit.

“Where are Mike and Liz?” asked Molly, changing the subject.

“They decided not to overwhelm you with another pair of greeters,” replied Paul. “They’ll be here tonight at 8 p.m. for supper, along with George Tobin—Mike’s cousin—and his wife Cicie.”

“And the kids, of course,” added Jackie. “Four of them, but my girls usually help play with Shayda and Jason, who are just eighteen months old.”

“The house will be pretty full tonight,” confirmed Will.

Molly took a sip of the iced tea. “Mmmm, just right, Will. And you said you’d have breakfast for me, too.”

“I have a breakfast ready to make for you,” he replied. He rose and went into the kitchen to pull out the pancake batter and eggs and in a few minutes he had pancakes and fried eggs ready for her. She complimented him on the delicious breakfast and the incredibly fresh fruit he served. Meanwhile, Paul and Jackie updated Molly about

Samantha and Tracy, who were ten and completing third grade. Molly ate—heartily, Will noted—and asked Ethel about her work. When she finished, she yawned.

“I hate to break up the party, but I’ve been up since yestersol morning and been flying in weightlessness for four hours, so I need a nap. It can be short, but I need something.”

“Let me show you your place,” replied Ethel, rising.

“We’ll be back tonight,” promised Paul, rising. He gave his mother a kiss. “See you soon, mom.” Jackie kissed her as well and they headed for the front door while Ethel led her back to the kitchen. In the kitchen, they took a right into a hallway, stopping at the first door. Ethel opened it.

“Wow, this is a big space!” said Molly.

“It was Marshall’s and Liz’s rooms. One’s still a bedroom, but the other is a nice private living room and work area, and of course you have your own bathroom.”

“Who says the Marsians live in cramped little houses!”

“Well, a lot do, but we don’t! It’s the privilege of seniority. If you want to go outside, just backtrack through the living room. That’s also the easiest way to the Bahá’í temple, which is just thirty meters away.”

“I want to go see it later and say some prayers.”

“The door is programmed to let you in via voice command. Will plans to come home to take you to lunch, but I’ll be at work until 5:30. You can always call me, though.”

“No, I’ll let you get your work done. Thanks for everything, Ethel.”

“Oh, it’s nothing.”

Molly embraced her and Ethel could feel a certain fear or anxiety in her sister in law. She nodded in good bye and stepped out.

Molly explored the apartment, unpacked—finding things like hangers and spare linens as she went—then laid down to nap. But as tired as she was, she couldn't sleep; there were too many unknowns and too many worries about the unknowns. Finally she grabbed her prayer book and walked to the Bahá'í House of Worship, a simple domed structure able to seat about two hundred people set amidst beautiful, lush gardens. That calmed her, but didn't resolve any of her dilemmas. She went back to the house and did manage to sleep.

“I'm glad you were able to meet me now,” Ramesh Pradhan said to Tree Rivers when the latter entered the construction control shack. “As I said, I'm on my way to Uzboi tomorrow for two weeks, so this is the only time we can talk.”

“That's fine; no problem” replied Rivers. “I have a pretty flexible schedule.”

“What brings you to Aurorae? Arrivals?”

“Exactly. They're trickling down awfully slowly; a dozen each flight. If Spacelift would fly them all down in three flights, it'd be much easier for us.”

“I'm sure, but Spacelift has a lot of cargo to land, as well as almost a thousand passengers. As you know, the earlier departures got delayed and everyone ended up flying here at once. So they're sitting on their ships and wandering all over Phobos Outpost.” Ramesh pointed out the window at a behemoth operating in the construction site a hundred meters away; the construction shack was located in Congo Dome on top of

Layercake Mesa where it had an incredible view of both Caribbean and Mediterranean.

“That thing took parts of two cargo flights, all by itself.”

“What does it do?”

“Everything! It can continuously excavate a trench five meters deep and eight meters wide, process all the regolith, extract the nickel iron and magnetite, crush sedimentary rocks up to forty centimeters across into pieces less than a centimeter across, sieve out the gravel, pea-sized stuff, sand, and dust, and place them in separate wheeled bins at once. The bins can separate themselves and drive away robotically when they’re full and another bin can dock in place. A hose brings it heated water so that the reg processor can wash the processed materials, extracting all the released oxygen and ozone, which are expelled out another hose and stored. The waste water is usually salty and is routed back into the outpost for disposal. We’re using it to prepare the ground for both Caribbean and Mediterranean and the regolith it processes will produce about a tenth of the oxygen the enclosure needs.”

“How fast does it move?”

Ramesh laughed. “Three meters an hour! It’s slow; Caribbean alone will take it one year to prepare the ground. We had already done half of it with our old equipment, though, so it’ll finish the work in six months, then on to Mediterranean.” Ramesh smiled proudly. “It’s even bigger; five hundred meters wide by seven hundred. It’ll have enough polder to support almost 3,000 people by our new standards of 150 square meters per person. And both of them will be finished in two years!” He pointed to the control room around him, which had three operators. “Three staff, working 24.6 hours per sol, are doing all the pile driving and regolith preparation. It takes another twenty-one, staggered

over three shifts, to make the plastics and shape them into the Kevlar ‘net’ and the actual dome. Our new machine can produce strips twenty meters wide. Nine more operate the equipment to spin nickel-steel wire and make the cabling; each strip has one cable on its ‘right’ side and it utilizes the cable on the ‘right’ side of the next strip as well. It only takes two people to operate the equipment that produce the thirty-meter nickel-steel pylons that we drive into the ground. We have two dome laying trucks that roll out the strips. Four two-person teams operate equipment to connect the strips together. Two teams operate equipment to attach the cables to the pylons. Four more teams attach cables to a row of pylons that run down the center of the dome. So we are making these enormous domes with a total staff of about sixty people. As you can see, Caribbean is up; it soars 150 meters in the center, which is so high that someone on the ground in the center has seventy-five kilograms of air per square meter overhead, which isn’t bad radiation shielding all by itself! It’s equal to the entire mass of Martian atmosphere above the dome! Right now the internal pressure is only four times Martian ambient; just enough to hold the dome up while we process the ground, flood it with at least a tonne of water per square meter, and tinker with the hold-down cables. It takes a while to balance the stresses on them. That process will be done in six months, at which point the air pressure will rise to our standard third of an atmosphere. We hope to get Mediterranean up in about nine months so the reg processor can get in there; by then we’ll have a second one assembled.”

“The size of the spaces is really amazing,” said Tree, looking at Caribbean. Mediterranean was still a long, raw construction site with a dozen pile drivers forcing

long nickel-steel stakes into the ground, but Caribbean soared elegantly to a height no one had ever seen on Mars before. “Will the domes come with reflectors as well?”

“Yes, that’s standard, and as you can imagine the system will be enormous. The interdomal area is the proof; if we weren’t planning to reflect extra morning and evening light in, we wouldn’t make the interdomal 150 meters wide. A lot of it has already been sold to housing companies, who will install underground housing there.”

“And you’re planning to build domes like Mediterranean at the other outposts, too?”

“Eventually; it depends on the political pressure, frankly. Everyone is jealous that Aurorae is so big and want it to have a smaller fraction of our total population. But it has the billion-reddack factories to make the Kevlar, nomex, and other plastics, and it can make the pylons and cables from the left-over nickel steel from earlier PGM production here. It also has the deuterium extraction facility that produces millions of tonnes of ‘waste’ water every year. Caribbean dome will mass a thousand tonnes, including the pylons and cabling. That’s a lot stuff to move to Dawes, five thousand kilometers from here, or even to Uzboi, 1600 kilometers away. Elysium has to make do with H-75s because of transportation costs!”

“The metal roads will help.”

“Yes, they’ll make transportation much cheaper, but it’ll be decades before we spread the metal paving very far. We’ll start with steep stretches, though, which will make them safer and faster.”

“There are a lot of them near Aram. What about the pipeline? Aram could use that because we can’t afford a reactor and our solar arrays are getting pretty big.”

“The pipelines—one for oxygen, one for methane—sometimes will be extended independently of the paving machines, but it still may take a decade for a pipeline to reach Aram. As it extends, it’ll serve as a gas storage facility and will be filled kilometer by kilometer. Every oasis along the road will have a few kilometers of metal road surface with piping and will store its own gas production in them. It may be a decade before the power production of any outpost can be shipped to another outpost via the pipelines. But as the system is extended, it’ll open up hundreds of thousands of square kilometers to settlement because people will be able to tap the pipeline to get oxygen, water, and power.”

“So, how much would a dome like Caribbean cost Aram?”

Ramesh thought a moment. “We’d keep the control room here. We have a nice view of everything on top of Layercake Mesa, but we very rarely use it. Getting the reg sorter to Aram would be a huge problem.”

“We could handle the reg ourselves. We don’t do much processing; the Aram plateau is pretty fine grained anyway, and the plants do the rest.”

“Okay. Assuming you have enough water and power, hauling the new pile drivers there, driving in the dome materials . . . maybe thirty million redbacks. That doesn’t include the development of the equipment; we’ve spent nearly two billion redbacks on the construction system over almost thirty years. By policy, we don’t include it. The costs would include hauling in the parts from Earth and maintenance.”

Tree nodded. “That’s a good price. That’s . . . 150 redbacks per square meter, which is tiny compared to your old prices. We’d recoup that in maybe ten years through the sale of agricultural products.”

“We’ve mechanized so much of the process, especially the production processes.”

“Now, how much would it cost to launch a version of the dome to space and wrap it around an asteroid a hundred or two meters across?”

Ramesh looked at him, surprised. He smiled like the question was naïve. “How would you drive the piles?”

“No, no. No pylons or pile drivers. The dome would wrap around to itself, a sphere above the asteroid’s surface, anchored to two towers.”

“So, the dome material and cabling. How would you handle micrometeoroids?”

“We’d nest three domes inside each other and pump escaping gas back in until the domes could be patched. Our interplanetary experience over the last century allows us to characterize that problem pretty well.”

“True enough. Where would the air and water come from?”

“The asteroid itself, which would have to be carbonaceous or a cometary nucleus.”

“You’ve thought this through.”

“Not really. There are all sorts of studies out there, including a very detailed one by the Venus-Mercury Commission a decade ago. They want a captured asteroid in Venus orbit.”

“I don’t blame them; it’s the only way to develop a long-term presence there.”

Ramesh thought some more. “I wouldn’t manufacture the dome here and haul it to orbit; too expensive. I’d manufacture it on Phobos.”

“Phobos? You’d do that, for a project like this?”

“Not for a project like this, no, but demand for specialized plastics and metal parts in low Earth orbit is growing, and our ship building operation is limited by launch of materials from the Martian surface. As launch to low Earth orbit from Earth gets cheaper, Phobos needs to make more of its own materials and parts; that’s something no one can do in low Earth orbit! Phobos could be the chief supplier for many of the materials orbital factories need.”

“When will this happen?”

“The next five to ten years, depending on the terrestrial and Marsian economies and the cost of the Prometheus shuttle, which will be used here as well as Earth.”

“That’s pretty soon. I had no idea.”

“I think with economic recovery, things will move fast. There’s strong interest in a Uranus and in a Neptune project, for example. I’d talk to the Venus Commission because if they were interested in this project, they’d split the costs with you and would lend your effort some weight.”

Tree smiled. “Thank you, I appreciate the advice. That’s a very good idea.”

The ringing sound wouldn’t stop.

Molly awoke suddenly and sat up in the bed. She was disoriented for a moment; where was she? Then she remembered: the guest apartment in Will and Ethel’s house. The ringing was her communicator, as they called them on Mars, the cell phone she had bought at the West Texas Spaceport that worked on Earth and in space and could switch between Earth and Mars time. She saw it and picked it up; it had stopped ringing, but she saw it had been Will. She called him back.

“Molly? Sorry I’m late, we had some emergencies.”

“What time is it?”

“One p.m. I was planning to come home for lunch.”

“I was asleep; I must have slept two hours. I don’t want to take you from your work, though.”

“Don’t worry about that, I have the time now. Do you think you can make it to Andalus Square? I’ll meet you outside the Commonwealth building.”

“Sure, that’s easy; out the front door and turn right. Give me five minutes, though.”

“Okay, five minutes, then. Bye.” Will closed the line. Molly put the communicator in her pocket and freshened up, then headed to Andalus Square. Will was seated on the steps of the Commonwealth building, waiting. He stood up as she approached.

“Do you want some lunch?”

“I’m not particularly hungry; that breakfast was quite nice. But I can have a coffee if you want to eat.”

“No, I want to walk, how’s that? I’ll show you around a bit.”

“Sure. This is a big place!”

“Thirty enclosures; we don’t have streets, so you have to memorize dome names instead. We’ll go through Cathay, Punjab, Zanzibar, Liberty, El Dorado, and Baltic and climb to the top of Boat Rock where we’ll have a nice view of the outpost and the area around it.”

“Okay. I might as well see my new environment.” They started toward the west tunnel leading out of Andalus. “What was your emergency?”

“Two, actually. We usually have one a month, not two in one morning! The cargo shuttle *Dzigai* left Phobos with forty tonnes of cargo and twenty tonnes of extra oxygen for Dawes and had an anomaly with engine 4. It’s probably nothing, but we don’t want it to fail on the way down, so the *Dzigai* is on its way back to Phobos to be checked out. Meanwhile, there won’t be any passenger flights for a few days while we verify the problem isn’t systemic.”

“So, people will be stuck on Phobos?”

“Yes, for a while. But with all the greenhouses and its zero-gee gymns, it’s a great place to be stuck, fortunately. The crew there can’t give people space suit tours of the place fast enough. While we were dealing with the *Dzigai*, a geologist on the Thaumasia expedition—it’s a mountain range a couple thousand kilometers southwest of here—had the computer of his pressure suit fail, so he had to head inside the mobilab to get a replacement. But he’s fine.”

“Sounds like these things keep you busy.”

“These are minor and I just watch and am available, the staff handles them pretty smoothly. This is a dangerous place. Last year someone on an expedition fell and broke a leg and had to be flown back here. The year before that someone cracked their helmet and nearly died. We have an industrial accident every two or three years, too.” He shrugged and pointed. “Cathay Enclosure and classic Chinese architecture.”

“Wow, very nice. You all live in a world town.”

“We do. ‘Mars is one country, and mankind its citizens,’ to make a paraphrase.”

They passed into the central, “River Walk” part of Cathay where a winding stream threaded between the two lines of buildings. “How many people in here are Chinese?”

“Maybe half, and Chinese live elsewhere, too.” Will pointed to a restaurant. “Really great Chinese food, and they deliver.” He led her past the restaurant and through a narrow alley on the other side to a door that said “private tunnel.” He pulled the pressure door open. “This crosses to Punjab through a B-75, so you can see a private housing development.”

They entered a tunnel three meters wide. Four times they passed gardens five meters wide and thirty-five deep with five levels of apartments open onto the garden, three levels below them and one above them. “Pleasant looking, but rather packed together.”

“We are packed together, but we have parks; you’ll see what I mean. No worse than Tokyo. This B-75 is 75 meters long, 35 meters wide at the bottom, 18 meters high, and houses about 150 people.”

They entered Punjab with its Indian architecture. “The best Indian food on Mars,” Will said, pointing to a restaurant on Indus Square.

“How many Indian restaurants do you have?”

“One! But it is good.” He pointed to the Hindu temple. “The priest there is really great, and active in interfaith.”

“Is this Indian or Pakistani?”

“Yes. Both. And again, half the population is not from South Asia. There’s a little ‘buffer dome’ north of here called Columbo and one south of this one named Himalaya.”

He pointed to the main public tunnel—six meters wide—and they headed to Zanzibar. Its buildings started Molly.

“Wood?”

“Don’t look too close. The exteriors of all our buildings are vinyl, even the ones that look like brick or stone; they just have an applique over the vinyl. And all the buildings either have gardens on their roofs or big water bags beneath them to protect us from cosmic radiation. These are based on the big wooden buildings on Madagascar.”

They continued west and entered Liberty. “Wow, we’re in the U.S.!”

“Did the miniature Statue of Liberty give it away, or the Mormon temple? The Texas Restaurant has great steak, but it’s expensive. A lot of the Latter Day Saints are in here, but again it’s very diverse. They do a country music concert here first Saturdays of the month.”

“The houses look like a suburb, too!”

“Yes, though they are townhouses. Each unit has its own back yard! Rather expensive, though.”

They entered the next tunnel and soon were in El Dorado, the Latin American enclosure. “Plaza de San Juan Cupertino,” said Will, pointing to the focus of the dome.

“A classic Latin American central plaza, with trees in the middle.”

“The only thing missing are the tree sloths,” quipped Molly.

“No, none of them. And this is the Cathedral of San Juan Cupertino, patron saint of astronauts because he supposedly could fly. The center of Catholic activity on Mars.”

She pointed to an underground entrance. “And this is a stop on the underground bus line?”

“Correct, here, Andalus, and Cochabamba, and it’s being extended west. The little carts there are for rent. You can walk up to one, punch on your communicator app, climb on, and tell it where to take you. Every dome has a parking spot for them. But most people walk unless they have bags of stuff they bought. The carts cost five redbacks per ride.”

They crossed the square, passed through another tunnel, and entered Baltic.
“Wow, this is bigger!”

“One hundred meters wide rather than seventy. The buildings all look like northern European brick structures. There’s a good Russian restaurant here, a small Orthodox chapel is opening here, and the Saturn Commission offices are here. We’re going up the mountain.” He pointed south, so they went halfway across the square and turned left. They passed through a pair of pressure doors rather than a tunnel and suddenly they were in a dome at the edge of Layercake Mesa. A marsh full of reeds greeted them.

“Mosquitoes?”

“Absolutely not! But there are a lot of pretty dragonflies. They scare the kids plenty. This marsh was unplanned, but all the water that we put on the slope to keep it watertight has to end up somewhere, so there are several dozen springs at the base of the slope, and a few actually make little brooks.”

They crossed the marsh on a footbridge and were at the base of a steep ski slope with a forested slope of boulders on both sides.

“That’s a long way up!”

“It looks worse than it is because of Martian gravity. There’s a trail through the boulders. It’s early summer in here right now; Baltic South has four seasons per annum or Martian year, rather than eight seasons per annum, because the slope faces north, so when the sun is in the southern hemisphere it gets relatively little light.” He pointed to a winding trail that cut across the boulder field and they started up. Between the boulders were pockets of soil with birches and firs growing in them; after five years the trees had already grown five or six meters. It was hot in the enclosure and they were soon sweating, but in ten minutes they reached the staircase cut in the cliff. They walked up and sat on a bench facing the escarpment twenty kilometers north of them.

“What an amazing view!” said Molly. “You can see the entire outpost! The entire valley!”

“Horizon to horizon. When you see the desolation outside and the verdure inside, you get a sense of what we have accomplished. It’s pretty impressive.”

“It is!” She looked at the slowly turning wind turbines south of them on top of Layercake; the dome seemed to rise straight out of the bare bedrock. She turned back to the north. “The escarpment is really incredible.”

“You could look at it forever. As the dust level in the air changes and the sun moves across the sky, its color changes. I used to be able to see it in my old office, and I miss it.”

“And there are three more domes west of here!”

“Yes, Niger has our mosque and the architecture is part Mecca, part Timbuktu. Caribbean is inflated and as you can see, it’s three times wider; three hundred meters. Mediterranean, beyond it, will be an incredible five hundred meters wide. They’ll be

agricultural for some time because we're building more and more underground H-75s between the domes."

"I may not need to learn how to use a pressure suit. This is quite a climb, and I can see the outside quite well."

"You should take a pressure suit class anyway. They're very easy to operate; they're automated, and they do have backup computers. The person who had the computer failure this morning was not in any danger. There are some great trails outside. Ethel and I go out for walks on Sunsols, sometimes."

"I suppose the class doesn't take long, either."

"A few hours, including your first EVA. But I didn't bring you up here just to see the beautiful place you're now living."

Molly looked at him, puzzled.

"For most people, this is what Mars is; a dazzling example of the success of technology to convert desolation into a new home for humanity, or a new frontier for science and medicine, or a chance to start over, or a chance to dedicate your life to a new, exciting enterprise. But the thing that makes this place work isn't machinery; it's love. And there's never enough of it. That's something you can bring to this world in abundance. I'm not just talking about volunteering. The Bahá'í community desperately needs dedicated workers; we're a community of devoted, well deepened, and slightly inactive Bahá'ís. We work too many hours. We all need care, hospitality, loving support, and friendship, and you can give these things."

"That's true. That's what mom did after she retired."

“Precisely. The Bahá'ís here need wise, experienced help, too. Most of them arrived here when they were in their twenties, when they had very little experience serving on local spiritual assemblies. You’ve lived in several different places and know how Bahá'í communities are supposed to work, and you have experience with them as well. We need that as well.”

“I can try.”

“That’s what I’m saying. There’s a lot of work for you to do here; don’t think of it as unemployment or even as retirement. There’s a mission here for you, if you want it.”

She laughed. “Does everyone up here have to have a mission?”

“I think everyone everywhere has to have a mission!”

She nodded. “You’re right; that’s why I’ve been feeling depressed over the last few months. The Bahá'í writings say exactly what you are saying: we have been created to carry forward an ever advancing civilization, and that’s a spiritual task, as well as a practical one.”

“And most people here are focused on the practical, so we need help with the spiritual!”

“That’s something I can do.” She nodded. “Let’s say some prayers here, then go down.”

Will glanced at the chronometer on his tablet again. Tree Rivers was late. He wondered whether that should mean a bigger penalty or not.

There was a knock on the door and Will looked up. “Can I come in?” asked Érico.

“Sure. My appointment is late; now he can wait instead. What can I do for you?”

“The Saturn Commission asked a team of nuclear engineers at Alamogordo to evaluate the performance of the gaseous core nuclear engines for trans-Mars injection and Mars orbit injection this columbiad. They’ve also looked back at earlier uses of the engines, including all the test runs over the last five years. They’ve concluded that the engines are good to send galleons to Saturn in one year.”

“Excellent, that’s essential for a Uranus mission, which would then take two years. What would be the travel time to Jupiter? Six months?”

“Yes, about that, and about one month, Earth to Mars. The engine would be needed to decelerate to a velocity that would permit aerobraking into Mars orbit. Aerobraking would suffice at Titan, though, because the atmosphere is so massive and deep. The study also indicates the vehicles would need heavier meteoroid armor because of their higher velocities, which would add about seventy-five tonnes to a galleon.”

“That makes sense, though you’d still need radiation shielding.”

“But we can use cargo for radiation shielding for the flight to Titan and it could have its own separate aerobraking system. That already was our plan. We can delay the launch of the *Cassini* about a month to add additional Kevlar armoring and send it to Saturn in one year with all the cargo.”

“Oh, that’s really good news! That solves a lot of problems. We’ll have to look at the report carefully for the next columbiad. If we use pairs of galleons to transport passengers here, each with its own gaseous core engine, and either engine could serve as a back up to the other in an emergency, we’d have very reliable and fast transportation. I bet each galleon could transport over a thousand on a one-month trip. Have you told the Titan mission?”

“I will in a few minutes. They’ll be thrilled. It means we can easily send a cargo and passenger flight every two years.”

“Good. I’m worried about the situation up there, with the vote to rent rather than buy and most people deciding to leave in the next few years. We have to do better. Either the outer solar system communities have to be larger or they have to have more frequent flights. I gather in 2078 and 2080 a flight to Saturn could stop at Jupiter, for example. The Saturn vehicles could provide an extra flight for personnel heading for Jupiter and would allow Jupiter personnel to go to Saturn, if they wished. In 2080 or 82, flights from Saturn to the inner solar system could stop at Jupiter and take personnel home, too. The 2080 opportunity could go on from Saturn to Uranus, too. In 2084 and 2096, there’s a Jupiter to Neptune alignment.”

“I doubt we’ll be ready by 2080 for the Uranus mission. I’ve also commissioned a study about exporting nitrogen from Titan. It sounds crazy, but if flights to Saturn carry cargo, flights from Saturn could do the same. We’re also looking at a backup plan for engine failure that involves timing the arrival at Earth or Mars so that a partial aerobrake will allow the vehicle to continue to Earth or Venus and perform a second aerobrake there, which will keep the vehicle in the inner solar system where a third aerobrake will stop it or it can be rescued.”

“There are so many possibilities now. Jupiter and Saturn will need to build up their refueling facilities. If we can maximize the number of visits they receive, give them exports, and expand the size of their communities, they’ll be viable long term human communities. I’m sure it’s possible. We just have to figure it out.”

“I agree.”

Huma stepped into the door. “Your appointment has arrived.”

“Thanks, Huma. And thanks for stopping by, Érico. This is very exciting news, with all sorts of implications.”

“It’s always good to brainstorm with you, Will.” Érico rose and stepped out. He passed Tree Rivers at the door.

Rivers looked at Will. “May I come in, now?”

“Yes, certainly. Sit down.” Will pointed to the seat at the table opposite him. “I suppose you’ve heard of the landing suspension?”

“Yes, I heard last night. Any idea when it’ll end?”

“Possibly tonight; the preliminary investigation suggests a sensor malfunction. We want to keep our perfect safety record. Which is also why I want to meet with you. We had agreed you could fly 150 people here on your caravel. Then we heard you had increased the total on board to 175 without our permission, which violates the use specifications of the vehicle. Then when your caravel docked to the *Isidis*, the captain of our galleon learned that you really had 200 on board. That’s actually more volume per person than the galleon and its 750 had, but the galleon had enough toilets, showers, and kitchens, and its life support system was set up for 750. So your people left their fairly large state rooms and crowded into our public spaces, flushed our toilets, used our cafeterias, and strained our facilities, causing lots of mechanical problems. The galleon actually massed two tonnes more than expected when it was preparing for aerobraking because of all the waste they left in the tanks, requiring an emergency purge twelve hours before arrival. The extra people also flooded the zero-gee gym.”

“They were dedicated to zero-gee volleyball and wanted to win the intership championship,” injected Rivers. “Look, I apologize for the problems. We promised the Zen monastery 30 berths and they were able to fill them all, then at the last minute we had extra people available and could buy seats on the Brazilian shuttle. There were plenty of consumables available at Gateway and we knew it, so the extra people arrived, we bought the consumables, we had the hydrogen for TMI, so we did it. We had three people stuffed into staterooms designed for two.”

“Whereas we had smaller, efficiently designed quarters and everyone had a comfortable bed. But you’re underestimating the safety risk, Tree. Your caravel had to change its aeropass trajectory so that it didn’t go as low because it was lighter than expected. Our galleon, in contrast, had to go lower even after the purge of its tanks. They almost jettisoned the zero gee gyms. Every mid course correction had to be recalculated. Supplies of spare parts were strained. The rotation axis required constant rebalancing.”

“I understand, and again, I apologize. I can assure it won’t happen again.”

“I am pretty sure of that as well. Step one: We’ll require far more detailed information next time before your ship can accompany ours, let alone dock with it. Step two: Write up an argument that caravels can carry more than 150 and seek a higher certification. Gas core engines have just been rated for longer burn times, which means a one-month flight from Earth to Mars with a Mars orbit injection burn is possible. A galleon can probably carry 1,000 for a month; a caravel, 350 if they are upgraded to hold that many. Step three: we can’t fine you without suing you in court, but we can charge you a surcharge for the inconvenience and potential danger, and you can always take us to court if you think it’s unfair, though I doubt public opinion would be sympathetic.

Each of those passengers would have cost you a quarter million redbacks on our galleon, so we're charging you a quarter million redbacks times fifty."

"What? That's highway robbery!"

"Like I said, you take safety seriously next time. If something had happened and people had died, we'd have a huge mess right now; a financial, political, social, even cultural mess. Twelve point five million redbacks, if you want our cooperation next columbiad. The bill will be in the email tomorrow." Will said it calmly and definitively. Rivers stared at him, furious. Will stared right back.

"Alright, have it your way." Rivers rose. "The check will be in the mail the sol after we get the bill."

8.

We Do Space

Early May 2072

Willie squirmed in Marshall's arms. "Ca . . ca . . col!"

"I know dear, it's cold in here, but we won't stay." Marshall wrapped his arms more tightly around Willie; S1 was a gigantic empty bubble in a gleaming white cavern, but it was well below zero. Amy tugged on his sleeve.

"Let's get out of here."

Marshall nodded and turned back to the airlock they had entered through, but just then the airlock entrance at the far side opened and in stepped four men in Titan suits, helmets on, liquid oxygen and methane bottles on their environmental control backpacks. They saw Marshall and waved so he paused and held Willie more tightly. They walked over, though they stopped five meters away; they didn't want any methane-saturated ice to pop off them and hit the family. "Strange to be able to see you like this!" said Marshall.

"We have to turn on the fans, so you'd better get out; you'll really freeze then!" said Chad.

"Okay." Marshall and Amy retreated to the airlock that accessed the rest of the outpost, but they left the door open momentarily because the airlock was still warm and fans weren't moving its air around. "We just need a locker room in here and everything will be great," said Marshall.

“With a heated floor, so we can put our stockinged feet down where our boots might have been!” said Chad. “But this will make the transition so much faster! There’s so much air in here, any methane we bring in will be diluted to a totally safe level.”

“I wish we had inaugurated this earlier. Now we need a door big enough to drive a rover or Mobilab in.”

“Next month, after the locker rooms have been moved here, they’ll move the garage here as well.”

“We just visited Adel,” said Amy. “He should be able to go home on Friday.”

“But he’ll lose two fingers?”

Marshall nodded. “They plan to amputate them tomorrow. There’s nothing they can do.”

“That’s too bad.” Three days earlier, Adel had accidentally exposed his right hand to Titan while helping to push a rover out of a rut. “It makes it that much harder for us to go outside.”

“We’ll have to reexamine all our protocols. We need to treat our titansuits as pressure suits, not as Antarctic clothing.”

“I really don’t like exploring via an Android-150,” exclaimed Teresa Alvaro. “It’s strange to call something with four legs, four different kinds of arms, two dozen camera-eyes, and a built-in geology lab in its ‘chest’ an android. It’s really not human-like at all.”

“But I bet you use the different arms and eyes when you can,” replied Amy.

“Sure, of course. But virtual reality isn’t the same thing as reality.”

“Is reality through a foggy helmet ‘reality’?” asked Amy. “If you want the real, unvarnished reality, you get frozen fingers.”

“The protocols will be adjusted pretty quickly and we’ll get back to normal operations,” said Marshall. “Besides, with the two caravels coming back, we’ll finally be able to get around this orange ball again.”

“Yes, Ontario Lacus; we’ve done some great virtual geology up there and need ground truth,” agreed Teresa.

Will waved goodbye and closed the inner airlock door, so they could exit to Acheron’s main tunnel. “You like to stir things up.”

“You geologists are always bellyaching about the androids,” replied Amy. “But you can move around just as fast as on foot, can see things better—you can zoom in—and can do better analysis. It’d be much safer for fingers and toes if you guys stayed inside and did your geology with the androids.”

“Yes, but the experience isn’t the same.”

“What experience? You’re wrapped up like the Michelin man in layers of insulation, it’s hard to move around, the helmet restricts your vision, and you can’t actually touch anything.”

“True, but . . . well, never mind.”

They turned left and walked two hundred meters along the main tunnel until they came to a big door labeled “N-4.” They opened it and passed through its airlock into the bubble. They entered at the third floor, where the cafeteria was located, though it had been moved to the rear of the bubble and the front area converted into commercial space. Ryoko Furukawa operated their store there and had her art studio behind. Maria Racan,

one of their fabrication specialists, had her weekend beauty salon across the corridor, and it was followed by one of their fitness areas; there were also such areas on the *Von Braun* and the *Korolev*. They went into the store, which as usual was unoccupied, and filled a bag they had brought with them with shampoo, clean diapers, a bag of fresh potato chips, a kilo of oranges, and some legos that Willie wanted. While they were paying, Ryoto stuck her head out of her studio. “Good afternoon!”

“Afternoon, Ryoko,” replied Marshall. “How’s your Saturday?”

“Pretty good. Daichi and I are going up to our cottage plot this afternoon to fill some pots and plant some flowers.”

“Oh, that’s a good idea,” said Amy. “We should stop by our cottage plot and let Willie run around.”

“But not plant anything?” asked Marshall.

“No, I do enough of that Monday through Friday, unless you want to.”

Marshall shrugged. “Maybe I will.”

“You can buy pots, if you’re interested.” Ryoko pointed to a display against the wall. “Say, Marshall, have you a moment? I’ve been trying to make simulated tholinstone. Sridhar thinks it’d be nice to cover the cafeteria walls with it, and people could use it in their cottages if they want, too. Come take a look.”

“Sure,” he said. She led the family back into her art studio, a long, thin room with tables covered by jars filled with plastic beads of many different colors. She stopped and picked up a panel a half meter square and two centimeters thick.

“Wow, that’s pretty good!” said Marshall.

“Titanian marble,” said Amy.

“I started with a marble formula because some tholinstone looks like marble; the stuff that isn’t black and ugly, anyway.”

“The white looks just like ice; it’s amazing,” said Marshall, looking closely. “And the flecks look like tholins and chondrite.”

“The stuff that looks like chondrite is chondrite. It’s readily available and easy to add to a plastic mix. I really like the yellow and tan veins.”

“Yes. There are some really pretty outcrops in Likoma.”

“I know, I looked at some of the virtual reality trips. Thanks, I’m glad you approve. You have a good eye.”

“You have amazing talent, Ryoko,” said Amy. “I’m glad you can now spend time on tasks like this.”

“I’m cleared to do art projects and run the store full time,” she replied. “For a while, anyway. We were planning to go back to Mars on the *Cassini*. But now that it’s arriving a year earlier, and another galleon will be here in 2075, we’ll wait for the next flight. Akio came back to Mars a few months ago after finishing graduate work in Japan in electrical engineering and plans to get married, so maybe we can persuade him to come here instead.”

“That’s a good idea,” said Marshall. “Alas, I don’t think I can persuade either of our sets of parents to come here! The new flight schedule really looks good.”

“Yes, it is very encouraging. One year each way: that’s not bad. Even Adel’s accident hasn’t dampened the enthusiasm!”

“That’s true,” agreed Marshall. “Our morale goes up and down, and now it’s up again.”

“Well, the *Cassini* is on the way, after all! And with twenty-three fewer people leaving, we may actually have a problem accommodating everyone.”

“Yes, Yuri and Sridhar are scrambling. It’s a good problem to have. Say hello to Akio, next time you talk to him,” said Marshall, waving goodbye.

Ryoko nodded. “I will, Marshall. Thanks for taking a look.”

Marshall and Amy went back into the store and he grabbed a pot and scanned it. They put the bag in it. “You walk a while, now,” he said to Willie putting down the 19 month old. The boy took his mother’s hand, whimpering a bit.

They walked back into the main tunnel and turned into N-5. They entered the bubble at the agricultural level; a four-meter ceiling, painted white, reflected bright lights around and a stand of corn faced them. They headed up the spiral ramp to the top through a cavernous, unused space. When they opened the door to the park level, Willie immediately knew what to do; he let go of Amy’s hand and began to run. Several free range chickens saw him coming and scattered.

Marshall and Amy laughed and watched him go. When he reached the far side, almost 75 meters away, he turned around and ran back. In the low gravity his run was really a series of long, low leaps.

They saw him coming back, so they walked along the edge of the bubble to the site of their future cottage. The dirt had been pushed off the last ten meters of surface at each end of the bubble in preparation for the construction of eight simple metal and vinyl boxes four meters wide and nine deep, with windows facing the grass and trees. The roofs of the boxes would be patios overlooking the bubble; anyone who needed more space could have another floor or even two below the park level and a partial second

floor above it. Marshall and Amy hadn't yet decided how they would divide their cottage, but they had decided on adding a lower level.

Marshall stopped when he thought he had reached their plot and pulled the bag of items out of the pot. He took the pot to the pile of dirt and filled it with his hands. When he finished, he moved it to the middle of their plot. "There! Now we just need a plant!"

"Roses, like your dad? We can get some."

"Maybe, but I've always wanted to have a small garden, so I think I want a tomato or a cucumber."

Amy laughed. "Alright, we can get one. Any idea when we'll get our first level?"

"They're building the cottages in S-4 and have finished them in N-4. The cottages are pretty simple and basic, so they should go up pretty fast."

"I'm not looking forward to painting and installing the rugs."

"It'll be fun. The lower level will be another year, though." He looked across the park. "The big problem will be going back to our apartment on the *von Braun*. This will be bigger and more comfortable."

"But has too little gravity. We'll enjoy this place on the weekends, though."

Marshall nodded. "Yes, I think we will."

"Riviera Biome just doesn't look the same," Will observed to Ethel and Molly as they entered it.

"No, the mature vegetation and the bigger dome makes it look different," agreed Ethel.

“That was our flat, there,” Will said to Molly, pointing to a series of second story windows. “It was residence number four; our current house being number five. This biome was finished during the sixth columbiad; 2047, I think, so it’s twenty-five years old.”

“That explains the big trees.”

“What’s left of them, we cut down half of them two years ago when we needed wood, during the import cutoff.” Will pointed upward to the domes. “You can see a second dome way above the first. We put that around all four of our original biomes—Yalta, Riviera, Catalina, and Shikuku—five years ago when the engineers determined that the existing domes were getting fatigued. The double dome should be good for fifty years.”

“And now this entire building is the Aurorae Cultural Center,” added Ethel. “We never would have thought of having such a thing, even a decade ago.”

They entered through the revolving door. Straight ahead was a stair to the lower level with a sign that said “painting, clay, and mosaic studio.” To the right was a small recital hall with a piano and a hundred seats; to the left was Liz’s dance studio. They went upstairs to the gallery, which filled the entire top level. The right side was an exhibit of contemporary Marsian painting and sculpture; they turned left into the other gallery, which had a special Impressionist exhibit. The space was filling up with a hundred or so guests, invited to thank Madhu for her service.

They lined up to shake hands with Madhu and greet Liz, who was replacing her as Director. Molly looked at a Monet on the wall. “That’s a really good copy.”

“I think that’s an original on loan from the Musée d’Orsay,” replied Will. “We do have two original Impressionists on loan for this columbiad. But the rest are *good* copies! We have tens of thousands of high-quality digital files.”

They reached Madhu. Will gave her a hug. “Thank you for thirty-four years of service to Mars.”

“Thanks, Will. I plan to continue my art, and I have a new project that Agmar just approved this morning: they’re turning the rooftop garden over to the cultural center and we’ll set up a botanical garden up there.”

“Really? That’s a great idea! And it’ll bring more people here.”

“That’s one reason we plan to do it. We need to give people enough services so they feel they should pay an annual membership fee!”

“We’ve joined!” exclaimed Molly.

“Madhu, this is my sister, Molly Nuri, who just arrived.”

“I’ve heard about your ordeal and I’m so sorry they burned your house. But Earth’s loss is Mars’s gain.”

“Yes, I suppose. I’m planning to help out with the Center once I’ve finished settling in. I hear you’re involved in interfaith activities, too. The Aurorae Spiritual Assembly has asked me to be their new interfaith coordinator. Perhaps we can have lunch some time?”

“That would be great; Will has all my contact information.”

They moved past Madhu to Liz, whom they hugged. Mike was with her, too, looking proud. Molly and Ethel stopped to talk while Will walked over to Yoshiyaki Suzuki, abbot of the Zen Monastery.

“Good sol. I haven’t seen you for months.”

“It’s good to see you again, Will.” They shook hands. “You must be so proud.”

“I am. She’s director of a pretty big institution, five months shy of her thirtieth birthday. A big space with only one other full-time employee!”

“But with more and more people like Madhu moving into retirement, there’s a growing pool of volunteers.”

“Yes, very true. So how’s everything up at the monastery?”

“Crowded. We’re housing the twenty-five Japanese arrivals until their apartments are ready. Little Tokyo didn’t have enough time to prepare. But we’re glad to do it, and it strengthens our role in the community.”

“And you’re holding meditation classes next door at Martech, right?”

“Yes, and they’re pretty popular. They are doing a lot of good for a lot of people. Marsians need to slow down and look at things as they are, not as they think or want them to be.”

“That is so typical of the human condition, is it not? And if we aspire to make things new or better, we need to see things as they really are *and* as they might be.”

“So true,” said Yoshi. He looked at the crowd, which included many prominent people; the Mayor, City and Commonwealth Council members, cabinet members, ambassadors, and the Chancellor of Martech. “So, have you gone to see the Ussuri brown bears yet?”

“What?” Will thought he had misheard Yoshi, the comment was so out of context.

“The bears. You’d think Japan was too prostrated by the war and the big Tokyo earthquake to fulfill its commitment to a Hokkaido Bioarchive, but no, it wasn’t.”

“We were quite surprised they weren’t sure whether they’d rebuild their spaceport, but they were sure they wanted to send two Ussuri bears!”

“We were laughing at that. You should talk to Ichiro Otsu about it. Over the last few months he has been patiently video mailing just about everyone with influence on Japanese space policy about the country’s future direction in space. He’s arguing that Japan needs a policy with four crucial elements; a spaceport, an industrial presence at the LEO industrial park that’s being rebuilt, a commitment to expanding Little Tokyo significantly, and a commitment to the Uranus mission. The first is essential for all the others, the second is essential for the country’s continuing prominence in engineering, the third is our role in Marsian society—which will be a key society for humanity’s future—and the fourth will put us at the cutting edge of exploration.”

“No commitment to Grimaldi?”

“We’re better off contributing to Peary than maintaining a very small, isolated national lunar base.”

Will nodded. “I’ll talk to Ichiro.” He saw Madhu and Liz climbing onto the speaker’s platform. “We’re starting.” He walked toward the platform, as he had to say a few words.

Liz began by praising Madhu, recounting stories from her childhood about Madhu’s kindness and devotion to artistic endeavor. Roger and several of her friends followed, then Will spoke briefly and gave her a plaque for her years of service to the Commonwealth. Finally, Madhu spoke briefly and everyone gave her a standing ovation. It was a beautiful, touching farewell gathering.

“I’m glad you’ll still be here as a volunteer,” said Liz to her afterward. “We really need you!”

“I’m looking forward to being free of administrative duties so I can concentrate on actual art projects. There are a dozen places where we can complete mosaics outside where they are easily visible. There are great swaths of concrete or metal walls that can be covered with murals. I have a lot of projects. I just hope you can get to the dance projects you want to do; this place takes a lot of time to run!”

“I’m afraid I’ve already discovered that!”

“I’ll keep reminding her that we all want to see her dance, not just the kids she trains,” added Mike.

“We need a space with a higher ceiling than the room downstairs,” noted Will. “I’m glad Martech has made its auditorium available on a regular basis.”

Just then, Will’s communicator vibrated. He picked it up and looked at the screen. It said *Will, Dr. Ambassador Tao wants to see you in 30 minutes. Huma.*

“Hum.” He turned to Ethel. “I may need to join all of you at dinner; something has come up.”

“It always does,” she replied, resigned to his departure.

He texted back. *Okay, I’m on my way* and headed for his office. When Tao wanted to see him urgently, it was rarely positive. He made the ambassador a cup of coffee; it was hot and steaming when Zhao Tao arrived.

“Your hospitality is always a balm for difficult discussions,” he began. He took a sip of the coffee and sat. “Perfect, as usual, Chief Minister Will.”

“How can I help you, Dr. Ambassador?”

Tao smiled. “My government is very concerned about the proposals that keep coming to the Jupiter Commission from Mars. The geology team here has proposed the import of a series of H-75s such as Titan has and the excavation of a very large underground facility so that geological exploration of the Galileans can be expanded. Marcraft has sent proposals for the sale of galleons every six months for a year and a half. The new Alamogordo study that says gaseous core engines can get a mission to Jupiter in six months has been used to press us for annual crew rotation flights. The Saturn Commission is pushing for a flight from Mars or Earth to Jupiter and then to Saturn in 2076, 2077, or 2078. And now there’s a study that recommends a flight to Uranus via Jupiter in 2078, 2079, or 2080. This is becoming excessive; really, it appears to be coordinated lobbying. My government hereby lodges an official protest with the Martian Commonwealth government about the matter and request that we not be pressed about Jupiter at this time.”

“I see. Dr. Ambassador, there has been no coordinated lobbying. The Saturn Commission is separate and I have heard about their proposals the same way everyone else has. The question of ramping up the geological exploration of the Galileans was the result of a seminar about their geology at Martech, in which several geologists at Callisto participated via videomail. I have read their report, and if you read it even quickly you will see that it is not an in-depth, detailed study. Graduate students wrote a lot of it. Most of their conclusions are rather obvious and hardly constitute lobbying. Marcraft is always writing agencies about ways their products can be used; that’s to be expected. The Jupiter to Uranus flight opportunities are a matter of orbital mechanics and the Uranus Working Group has publicized them. I met with some of the group members—the ones here on

Mars—and urged that they look at flights that connect the outer planets together, because the outposts there are so remote, they will benefit from having visitors for a month or so. And I’ve never heard of anyone arguing in favor of annual crew rotation! Mars has managed fine with flights every 26 months.”

“The geological report, as I understand it, did not come off as an amateur effort by graduate students. Its recommendations were quite specific and sophisticated.”

“Perhaps because half the faculty were on Callisto and knew exactly what they needed. When I was in graduate school, I participated in a similar seminar that made recommendations to NASA. It’s not an unusual exercise.”

“Perhaps not, but these efforts still come off as coordinated, and whether coordinated or not, Mr. Chief Minister, it appears that Mars is seeking dominance in the outer solar system, and China does not favor that situation. It wants flights originating from many nations on both planets and a widely dispersed collaboration.”

“We support that as well. Dr. Ambassador: we do space. That’s why we are here. China does many things, and well. But China, the United States, India, and Europe have cut way back on their space commitments since the war, and the ironic result is that Mars has become as large a player as any one else. We can do a lot in collaboration with others and seek exactly that collaboration. I have repeatedly said that it is our policy to commit ten to fifteen percent of our budget to exploration outside Martian space. We now have 9,000 workers on Mars, so that’s about 1,000 members of our workforce. Some of that consists of existing workers at New Hanford, Phobos, and Deimos, or who collaborate with them here. Some are geologists associated with Martech or ecologists associated with environmental management and bioarchive. With gold and PGM sales remaining

strong, we're also talking about 2 or 3 billion redbacks per year we can spend on Earth purchasing equipment and propellant, supporting cryoenvironmental engineering, etc. Over the last eighteen months since terrestrial launch capacity was restored, we have spent three billion redbacks restoring lunar propellant manufacturing capacity, rebuilding the Gateway facilities, launching cargo to Mercury, Venus, Ceres, Saturn, *and* Jupiter, paying for new Venus surface equipment and some of the equipment the others needed. . . we also have spent three billion on the Prometheus shuttle and five billion lifting our own cargo and personnel. And we spent some of that in China."

"We certainly are grateful for that. I'll forward your comments to my government, but your examples certainly have reinforced our concerns rather than relieving them! And until our concerns are relieved, you can't expect our cooperation in jovian space."

"Suit yourself. A launch opportunity from Mars to Jupiter is coming up next year and we can probably commit a galleon to it; Saturn has its galleon, and with the new report about gaseous core engines, we can pack four galleons of people into three on a 30 or 40-sol trip from Earth to Mars. A galleon to Jupiter will need substantial radiation shielding and that can be cargo, so we can easily add a half dozen H-75s. We have the money to send prospectors and the new Android-150s from the U.S. and Japan; the Galileans don't have any androids yet. Shall we explore the jovian system together, or not?"

Tao scowled at Will. "A tactic like that will make the cooperation of China less likely, not more."

“I’m sure. But let’s remember that Callisto is not the only moon outside the jovian Van Allen Belts. Parts of Ganymede have a manageable radiation environment, and there are various moons farther out. We have other options.”

“That doesn’t reflect your insistence on collaboration!”

“No, we want to collaborate. But Mars won’t be stonewalled, either.”

Tao nodded. “Alright, I’ll bring that matter to my government.” He rose, Will extended his hand and they shook, then said goodbye. As soon as Tao stepped out, Huma entered.

“You’re getting less accommodating,” she said.

“You think so? Maybe I’m getting impatient, in my old age. The situation in Jupiter space is very frustrating. The Chinese want to dominate it but don’t want to pay for the privilege, and don’t want anyone to upstage them. The biggest planet in the solar system, the biggest system of moons in terms of mass, the most diverse set of moons, and it’s being explored by sixty men and women hunkered down in two caravels under sandbags full of ice, driving a total of eight rovers across the surfaces of four moons.”

“Seven; one of the rovers on Io got smashed by a volcanic bomb last month, exploring Loki.”

“You’re right. Seven. And the four Galileans together have as much surface area as Mars, with more volcanoes, more craters, more water, an incredible record of the solar system’s building blocks in the meteorites in their crusts, life traces . . . after four decades we still don’t have this place figured out, so imagine how much work the Galileans require! The planet has the most dynamic weather anywhere, it’s part way to having

fusion in its core, it has rings, it has families of captured satellites as much as forty million kilometers out . . . Jupiter needs a community, ultimately, of thousands.”

“So, what can Mars do, and still have resources for the other planets?”

Will looked at her. “We need to coordinate our policy better, plan the use of our resources more efficiently, and leverage them with the help of other nations, and that means hiring someone.”

“Who?”

Will thought a moment. “Let’s call a meeting with three people: Yevgeny Lescov, Jacquie Collins, and Xiaopeng Cai. See whether we can arrange a time in the few weeks.”

The *Santa Maria* descended through Titan’s haze, firing its engines during the last thousand meters to slow its terminal velocity, and landed on Pad 4 two hundred meters east of the *von Braun* and *Korolev*. Half an hour later the *Victoria* followed, landing on pad 1 two hundred meters to the west. Both caravels lowered their exit tunnels to the surface, where suited crew joined their tunnels to a tunnel rising up from underground corridors that terminated a mere ten meters from each vehicle. The crew soon exited in their shirt sleeves straight to a hero’s welcome in Acheron Outpost.

“He has done it again!” proclaimed Yuri, raising his glass to toast Johnny after the welcoming dinner was over. “How many craters on Phoebe did you explore? Jason, Euphemus, Butes, Canthus, Phlias, Amphion, Talaus . . . thousands of samples of the lampblack-colored carbonaceous outer surface, detailed seismology of the ice mantle and tiny core, humanity’s first detailed exploration of a Kuiper Belt object, samples from the Phoebe ring even . . . it’s a little place, but no one will need to explore it again for a

decade, especially since we left a rover there so we could continue our work. Now we'll date the samples, date the craters, nail down Phoebe's evolution and arrival in the Saturn system, and really come to understand the place. Let us raise our glasses in salute to Johnny Lind, our first Kuiper Belt conqueror."

Everyone chuckled at that and Johnny smiled, pleased. To cries of, "Here! Here!" everyone downed their glasses. Yuri called on the thirty-eight crew to rise and receive their collective thanks, and everyone gave them a standing ovation.

"Thanks, Commander," said Johnny as everyone resumed eating.

"And your next proposed destination?" asked Yuri.

Johnny considered. "Pan, the 27-kilometer moonlet in the Encke gap in the A ring. It's relatively large, its equator is covered by accreted ring material, the gap is wide enough to get into safely."

Yuri nodded. "Spectacular photography, too. But it'll take a month or two, and the delta-v is pretty high."

"It's 7.4 kilometers per second; nothing the caravels can't handle with solid core nuclear engines. We can use some gravity assists from Titan to work our way in. We'd make fuel there in a month's time and head to Prometheus; much larger, but it's probably a rubble pile of ice blocks, in the middle of the F ring. I'd make the two of them the nominal mission and make Janus, Pandora, and Daphnis optional additions, in that order. The delta-vee to go from one to the next is pretty small, generally 100 meters per second."

"You'll definitely need both caravels, for safety, and a shuttle with a nuke."

“I’d like to take at least two rovers along to leave on Pan and maybe Prometheus. When can I leave? I have a core crew of twelve who will go.”

“Yes, I’m impressed; you’ve created a group of hard core explorers. Take the next six months to rest, analyze the data from Phoebe and write it up, and recruit your crew. Meanwhile, we’ll send out the *Victoria* and the *Santa Maria* alternately to sites here on Titan.”

“Why can’t they be explored remotely?”

“We need ground truth of the sort that only a visit can provide. The missions won’t last very long because any particular spot only has eight days of light. We’ll land a shuttle with a nuke, it’ll start to refill its tanks, then a caravel will fly out and explore the area, refuel, then the shuttle and caravel will relocate to another site about 180 degrees around Titan where the day is just starting. After three to five visits the caravel will return here, the crew will do their analysis, and the other caravel will go out. We’ve identified sixty priority sites.”

“And I can’t be in charge of these trips, too?”

“Tell you what; you can be in charge of half of them. Teresa Alvaro is in charge of Titan exploration and she needs access to the caravels to accomplish her job. We’ve been here at Acheron twenty-one months and the geologists have explored outward as much as three hundred kilometers, but they really can’t go farther in the rangers and Mobilhabs. This isn’t Mars. So far, almost every vehicle has been stuck in the mud at least once; that’s how Adel lost his fingers. All of them have developed cold-related mechanical problems. Even sending three vehicles out together is not safe. We need the mass of the caravels, the safety of their engines, and the power that a nuke provides.”

Johnny sighed. "Okay."

"I'm not trying to deprive you of equipment or of command, believe me."

"I believe you." He paused to look at Yuri. "Life is too short. Tad just finished high school a year early and he wants to go back to Mars. He's been talking to his mom and of course she wants him back, though he's talking about doing graduate work at Caltech if he can get in."

"That'll leave you alone here."

"I know, and with no marriage prospects, which would be nice, I think." He looked around. "So I'll probably return to Mars on the *Cassini*. I'm still not sure, yet."

"Well, you have quite a list of accomplishments here; more than most people can claim in a lifetime. And you're 56; you can still do more."

"I'll be too old to command the first Uranus mission though, if it doesn't launch until 2080. If it were a ten year mission, I'd be 74 at the end."

"Yes, that won't work. I'm three years older than you, so when I return to Mars about 2078 I'll be 64. I may go straight back to Earth, though. I don't know yet. I may even stay here until the 2080s."

"You easily could. Thanks for giving me these opportunities, Yuri. I figure after the ring mission, there will be time for one more, maybe to Mimas, Dione, and Tethys."

"The last three big moons."

"Well, why should I leave any of them for anyone else?" said Johnny, with a smile.

Yuri nodded. "Why indeed."

9.

Ministry of Space Exploration

Early June, 2072

I'm sorry I couldn't get to Aurorae sooner, but the hotel construction project at Tithonium, and our plans to open new anorthite and spodumene mines for aluminum and lithium production, kept me occupied for the last few weeks," said Jacquie Collins apologetically. "Fortunately, the problems with construction are resolved, the anorthite open pit mine is underway, and the spodumene mine is canceled for now."

"It creates a thirty tonne deficit in lithium production, but we'll manage," said Will. "The Thaumasia mountains may have minable deposits of spodumene, but we can always import the stuff. Never mind; we're here to focus on space exploration." He looked at Yevgeny Lescov, the Minister of Interplanetary Transport, and Xiaopeng Cai, one of their leading eobiologists. "Thanks so much for coming today. I want to consult with the three of you about the development of Mars's space policy, especially in the light of Andries's departure for Saturn last month as commander of the *Cassini*. His assistant has continued the work until I fill the vacancy, which I have delayed doing because the Ministry of Exploration has had two priority tasks since the position was created six years ago: exploration of Mars and exploration of the rest of the solar system. I think the dispatch of surface expeditions to visit remoter areas of Mars needs to be devolved to Martech and exploration of the solar system needs a position of its own, with a strong staff."

“We have pretty good relations with the different Commissions,” noted Yevgeny.
“Do we need another cabinet ministry?”

“Yes, I think we do,” replied Will. “Space exploration is part politics and part strategic vision. We do indeed have excellent relations with the stations or the Commissions for Mercury, Venus, Ceres, and Saturn. Currently we have no problem with the moon because we practically own it; we’re leasing most of the space for training our immigrants and we even have the contract for running Parenago. The difficulties arise with Jupiter and with planning the mission to Uranus. So that’s where I am hoping the two of you can help. Jacquie, I’m asking you to consider serving as the new Minister of Space Exploration. We’ll take Mars exploration out of the portfolio and give it to Martech. I want a minister who can build relations, but also one that can develop and articulate a vision for exploration of the solar system. What do you say?”

Collins was startled. “I’ll need to think about that. I suppose it means resigning as Commander of Tithonium and moving here.”

“Yes, I think so, because this is not a part time job.”

“I’ll need to talk to Mario. I suspect he’d favor this, but I have to check, obviously. Right now the position of Clerk of the Mars Council has kept me busy here and I’ve been going back and forth; not a good situation when you have a three year old! He has wanted me to resign from something to make life simpler.”

“This will involve less travel, but perhaps not less work,” replied Will. He turned to Xiaopeng Cai. “The big problem right now is relations with China and resolving all sorts of problems in jovian space, so I am wondering whether you want the job of Deputy Minister of Space Exploration with the China portfolio. As an eobiologist, you know the

work being done on the Galileans and know what can be accomplished if we can expand the operation on Callisto. You've been on Mars twenty-six years, your kids are just about grown up, you are thoroughly a part of the culture and politics here, yet I gather you have kept good contacts with the home country."

Xiaopeng smiled; he loved a challenge, and this clearly was an interesting one. "Thank you, Chief Minister Will, this would be a welcome opportunity. I have followed the work on Galilean bionts quite closely and have even considered spending time there. I was invited to participate on the first Chinese expedition back in '62, but my children couldn't have gone along and it would have been a six year commitment, so I had to decline."

"I'll be frank, Xiaopeng; you'd make a good next commander for the American-Marsian part of the Callisto operation, if we can get the Americans to agree to it. I'd like to plan for a really big expansion of operations there involving a galleon launch in 2074 and another galleon in 2076. I'd like to push the population on Callisto up to about 500, which is where it needs to be in the next phase of development of the jovian system. The limitation on us is primarily political, however; we have the resources. Mars could send out two galleons all by itself, but the result would be political trouble with big allies. But Jacquie is American and you are Chinese, and those are the two big allies we need to work with. I think the two of you can do it."

Xiaopeng and Jacquie looked at each other. They barely knew each other and had not anticipated working together. But both nodded.

"Good," said Will. "Now, one other matter: Uranus. We need someone to coordinate the planning, someone who could either become commander of the first

mission or Commissioner or both. I'd like the three of you to serve as a task force to suggest someone. Yevgeny is already on the working committee that is outlining a Uranus strategy. The system has had orbiters almost continuously for forty years and landers on one moon or another for most of the last twenty years. The place is fairly well known, so there is good preparation for a human presence. The operation there needs to be similar in scale to Saturn; at least two galleons and three hundred personnel, though one could argue for three galleons because of the distance. The Uranus planners also need to start thinking about Neptune, which will be the next target in another decade. It'll require better gaseous core engines and bigger vehicles, though, I think."

"Even with the new one-year trajectory to Saturn, Neptune is four years away," agreed Xiaopeng. "That's requires a big improvement in life support and possibly propulsion."

"But one that could result in transportation between Earth and Mars in 2 or 3 weeks," said Will. "And one that could allow immigration in the tens of thousands per columbiad. So we need to pursue it. There's a synergy between our expansion and exploration outward, and that's one example. Okay; any questions?"

"I feel underqualified for the job," said Jacquie. "I'm a civil engineer; I know how to organize and build outposts. I'm not a geologist or eobiologist, so I don't know the science, and I don't know the space technology aspects."

"But you know enough about the science and technology," replied Will. "This job does not require specialized scientific or engineering knowledge. It requires people skills, diplomacy, and creativity. The skills you brought to Clerk of the Mars Council are the skills this job needs."

“Who will I be talking to? The ambassadors?”

“No, we’ll do that together, but you’ll talk to their assistants and officials in the various space programs. You and Xiaopeng need to work together with China.”

“Who has contact authority with the moon?” asked Yevgeny, who was the usual contact.

“That falls under your area, Yevgeny, because our primary interaction with the lunar outposts and the governments in charge of them center on immigration. The only way we can get 4,000 people here in slightly less than two years is to send as many of them to the moon as possible as soon as possible. But Jacquie and Xiaopeng can and should talk to the commanders and staff anywhere else, and should feel to contact staffers on the moon and relevant experts who have been at any place off Earth or are still on Earth. Just focus the questions on Uranus. Call everyone on Callisto, if you want, and ask them: based on your experience, what needs to go into a Uranus mission? You’ll get plenty of ideas for Uranus and spontaneous information about the current situation. Ceres, Callisto, and Titan are our models for the Uranus mission and they are models for what can be done to improve each other. The budget for space exploration off Mars next fiscal year is still being determined by the cabinet, but it will probably be about two billion redbacks; a bit lower than this year’s and last year’s, because we need to preserve our accumulated surplus and because the price of gold and PGMs are declining.”

“I’d talk to people like Olaf Norlander, former commander of Mercury operations,” added Jacquie. “He has vast experience and now he’s a high official at ESA.”

“What’s the time frame for planning?” asked Xiaopeng.

“That depends. For the Uranus Project, we need to plan what we do before launch—tentatively, 2080—and an outline for the next five or six years. For Neptune, the planning horizon is twenty years with a launch in the 2085-90 range, maybe later. The Mercury, Venus, Asteroid, and Saturn Commissions have detailed plans, but our financial planning can speed them up or slow them down. With Jupiter, our launch window is mid 2074; more than two years from now. The big question is political: how much can we send?”

“What do we do about issues of autonomy? Stay away from them?” asked Jacquie.

Will considered. “You’re not in the position to speak officially for Mars about the autonomy or independence of the various outposts, but feel free to let people talk and ask questions. Mercury and Ceres are the farthest along, followed by Titan. They’re all electing their command structure now. No one knows what direction these worlds should go; what the next step is. They’re way too small and economically dependent for independence. It’s not even clear the population on those worlds is permanent; most will come and go.”

“One possible step could be called ‘trusteeship,’” said Jacquie. “Rather like the old Trusteeship Council of the United Nations, which oversaw the role of an outside government to coordinate and support the place.”

“Another model would be a ‘territory’ model like the Northern Mariana Islands,” said Will. “Mercury, Ceres, Titan could serve almost as honorary boroughs and elect non-voting representatives to the Mars Council. We’d serve as the umbrella government until they were ready for independence.”

“That could be complicated and messy,” observed Yevgeny. “We’d be remote and the people on these worlds would feel we were unresponsive and insensitive.”

“They already feel that way with their Commissions and national governments,” said Xiaopeng.

“I think you have enough to get started,” said Will. “When can you let us know your decision, Jacquie?”

“Give Mario and me a sol.”

“Xiaopeng?”

“The same.”

“Excellent. I have appreciated this discussion. I think we’re off to a good start.”

The waves on Ontario Lacus were five meters high and moved across the oily surface at an impossibly slow speed. Marshall faced into the wind—noticeably chilly even though it was a gentle breeze—and watched a wave crash into the base of a cliff nearby and blast a methane/ethane spray high into the air. The droplets fell back to the ground and sank into the mix of tholin and ice sand.

“I’m glad there’s a spot close enough to watch, but safe,” said Chad. “It’s pretty spectacular.”

“Just like the ‘waterfall’ we saw yesterday,” agreed Marshall. “Beautiful, but deadly.”

“Let’s get some good video,” replied Johnny. “This is just the stuff the people on Earth want to see.”

“It’ll be great on our Facebook pages, too,” agreed Marshall. All six members of the team spread out along the bluff and took video of the methane lake and its spectacular waves.

“The geomorphology, though, is our real purpose here,” said Johnny, after a few minutes. “Let’s get down to the bench.”

They all headed downhill, though not toward the lake; a valley spread out on their right crossed by a lazy methane river, and the bench, ten meters above the current level of the lake, had been a beach on the side of the valley just a decade earlier. They explored it systematically, stopping to pick up samples with tongs for close examination, photographing low beach ridges and trenching them to determine whether they had been made by waves or wind. The one seventh gravity, gentler breezes, and lower density liquids made for higher, slower waves that packed less punch than on the Earth, but were more spectacular. The “mud” was a mix of complex hydrocarbons and chondrite “clay,” the “sand” was usually ground up ice, and the “gravel” was often stony or nickel-iron meteor fragments; the waves sorted them into separate layers and zones, which they found by digging and examining. Chad Sutton was their expert about fluvial sediment transport, so he supervised the trenching and called people together to observe certain features.

“A lot of you guys went to the beach as kids,” quipped Marshall. “You have an advantage over me!”

“Oh, the poor Marsian kid,” replied Johnny, joking.

“Don’t worry, Marshall, I never went to the beach as a kid, either,” replied Soo. “I grew up a thousand kilometers from the sea!”

Just then there was a beep over everyone's microphones. It was Adel Mehmetoglu, who was providing support from inside the *Santa Maria*. "Radar shows a thunder shower forming about five kilometers south of your position and heading your way. It's pretty weak, but I suggest you guys head inside anyway."

"We copy, Adel," replied Johnny. "Thanks." He looked at the others. "Let's go. We've got enough data logged to keep us busy the rest of the day."

They all turned and headed for the caravel, which had landed a kilometer away on a flat area about a hundred meters above the shoreline. It was their first of five days at the site, which would involve exploring several canyons and the climbing of one small mountain peak, if the weather cooperated.

"So, how much of the landforms can you attribute to low gravity and how much to the working fluid?" Marshall asked Chad, as they trudged back in the overcast dimness across the frozen terrain.

"I don't know," replied Chad. "The methane-ethane mix is about 2/3 the density of water and its viscosity is a bit higher."

"Sounds like we need to develop a sand table back at Acheron," suggested Johnny. "We can simulate the ice-sand with plastic."

"The tholin and tholin-chondrite clays would be hard to simulate, but worth the effort," said Chad. "And no one else has our gravity, so only we can do it."

"I'd like to see more than just a sand table," suggested Marshall. "When I was a kid, our first biome had a swimming pool. I can't tell you what it was like to encounter that, as a ten year old! We have plenty of caverns and we can make nickel-steel plate pretty easily. It'd be easy to make a big pool of water. We could swim in it, we could

import tilapia—I don’t know why we didn’t bring some with us—and we could do sand table experiments.”

“That’d take a lot of insulation and heat energy,” said Johnny.

“We have the heat energy,” replied Chad. “The nukes expel half their heat into the Titanian atmosphere unused. Several layers of metal plate separated by air spaces would provide decent insulation, too.”

“Well, let’s take the idea to Yuri, then,” said Johnny. “The metal construction would take several months. I’d rather save the H-75s for use on the other moons, though.”

“We need pre-designed mini-stations,” suggested Marshall. “Rather like the standard oases Mars built.”

“Yes. No one thought we’d do so much exploration so early, so they weren’t part of the first flight. But they have to be part of the next flight.”

Kristoff Langlais looked at the long piles of composed organic matter that the robotic trailers had hauled overnight from his farm in Ukraine dome to Caribbean dome. The blackish material was steaming slightly because it was still undergoing some breakdown. He wondered where Jerry, the usual agent from Agmar that he dealt with, was. Then he saw Lisa Kok approaching.

“Good morning,” he said to her. He pointed. “The compost Agmar ordered. I’m waiting for Jerry to come see.”

“I thought I’d come down instead,” replied Lisa. “Fifty tonnes, right?”

“Fifty-three, according to the robotic loader. It took eleven trailer loads. They tied up the main tunnel from 2 to 5 a.m.”

“I’m sure you sent the data to us, so we’ll cut the check right away. What was it, wheat straw?”

“Mostly. It’ll be a good addition to the land, here.” He looked out over the northern half of Caribbean, which was planted in nitrogen-fixing soybeans. “What’s the next crop?”

“With the nitrogen and the compost, and a little fertilizer, we plan to plant sugar cane in part of it and jute in another part. That’s one reason I thought I’d stop by to see you. Are you interested in buying or leasing any of Caribbean?”

“Here?” Kristoff looked around. “I’ll tell you, I’ve specialized in crops that don’t do well in a tropical, humid climate. I have expertise in it, but I’d rather not pursue it at this time. I’d rather buy or lease the rest of Ukraine, or even a chunk of Mediterranean.” He turned west toward the construction area where work had started on the next big enclosure.

“Fair enough. I have a shortage of folks who want to specialize in tropical agriculture right now; that’s why I asked. But one possibility would be to plant citrus and other trees in here.”

“I really would rather acquire the rest of Ukraine. I’m not interested in real estate speculation. The farmland in here will probably get converted to urban space in a decade or two, and before that so many members of the public will be strolling through that they’ll interfere with the farm. That won’t happen with Ukraine, since it only has a factor of two overdesign for the pressure. What about a Caribbean north or a Mediterranean

north? There's plenty of room for big agricultural enclosures extending the footprints of these spaces."

"Ramesh is considering them, exactly for the reason you mention: they require less safety and can provide us farmland fairly cheaply. If you're serious about the rest of Ukraine, though, I think it can be arranged. We need to encourage more private farming and you're the largest private producer, except for the Green World community."

"Buy or lease; either way. I can easily double my land under cultivation. I have the equipment for it, now."

"I know. Alright, I'll look into it. Mediterranean will have a very similar climate, so we can move our operation there in about eighteen months, which will be more efficient for both of us. Meanwhile, we'll need another fifty tonnes of greenwaste for this place, and I'm sure we'll want a contract for Mediterranean."

"The oxygen, too." He looked up. "So much air overhead! And how deeply will the ground be thawed, underneath?"

"The bubble of Earth will eventually extend 150 meters downward in the middle of Mediterranean and 150 meters upward. Ramesh says if we can make an enclosure that extends upward 500 meters, we'll have a quarter tonne of air over every square meter and solar flares will be completely unimportant. If we can eventually make enclosures that extend upward a kilometer, we'll have a tonne of air above every square meter and cosmic radiation will begin to fade as a problem. I think those are the goals he's working toward. Even Caribbean and Mediterranean will be so large that the zoning won't require buildings to be airtight."

“That’s all amazing to contemplate. I’d better go; my nephew is about to leave Ceres and we’re expecting a video from Helmut and the family. Have a good sol, Lisa.”

“Thanks. Say hello to Helmut for me, when you get the chance.”

Kristoff nodded, waved goodbye, and headed for his home in Cathay. His father had promised to be there at 9 a.m. and that was now just a few minutes away, so he hurried his pace. It was a long walk; Caribbean was 150 meters from Baltic, so its tunnel alone was lengthy. The public transportation tunnel was not yet open for robotic busses, either, so he couldn’t use wheels. The area between Caribbean and Baltic hummed with activity because the two private construction companies were both busy building buried housing modules for the columbiad 19 arrivals. All the more reason not to farm in Caribbean; too many people would want to walk in the fields.

He got home at 9:09 and his father was already there. “They haven’t videomailed yet,” he said.

“Good, glad I didn’t miss anything.” Kristoff smiled. “I just saw Lisa Kok and she said she’d try to arrange for me to lease or buy the rest of Ukraine!”

“Really? Congratulations! That’ll definitely make you the largest private land owner on Mars!”

“What a strange thought. She said once Mediterranean opens, they’ll centralize their production there and I can use all of Ukraine.”

“We’d be better off buying Mediterranean,” said Irma. “It’ll be worth more in the future.”

“No, I don’t want to do that. I want farmland that will remain agricultural.”

“So, why is Agmar willing to sell?” asked Sebastian.

“They’re trying to diversify the agricultural sector. Gaston Gilmartin has gone into cattle, pig, and sheep raising and he got a big business-starter loan; one of business loans Henry Smith has championed. And Sophie Chen bought all of Andalus southeast—the dome next to the Bahá’í temple—and has flooded it for rice and tilapia farming.”

“That makes sense,” said Sebastian.

Just then the house’s phone line beeped with an incoming video message. “It’s them,” said Kristoff, checking the caller i.d. He pushed some icons and sent it to the wall screen. A picture of Helmut, Clara, and Charles appeared.

“Where’s Oskar?” said Sebastian.

“He’d be in school,” replied Irma. “Just like Mark and Nicola.”

“That’s right, Ceres just switched from days to sols,” said Sebastian. “Wow, Charles is so grown up!”

“He’s nineteen, dad,” said Kristoff. “Your grandson’s a man now.”

They had missed the beginning of the video, so they rewound to the beginning. “Greetings from Ceres!” exclaimed Helmut. “We wanted to say hello quickly because Charlie gets on the *Wolf* in less than two hours for blastoff to Lutetia and Mars, just 13 months from now!”

“Hi grandpa, uncle Kristoff and aunt Irma!” added Charles. “I’m looking forward to seeing all of you next year!”

“We just had a nice farewell breakfast together—all four of us, Oskar got to school a little late—and we’re back home to get Charlie’s luggage,” continued Helmut. “Please take care of Charlie for us, okay? Martech is giving him credit for the Lutetia

expedition, on top of the two semesters of online courses he's already completed, so he's off to a good start."

"And when I get there, I'm staying in the dorm," added Charles. "So you don't need to put me up or anything."

"Well, I wish he'd stay with someone for the first semester, while he gets adjusted."

"Oh, dad, I'll be fine, Aurorae isn't New York City or anything."

"Never mind," replied Helmut. "Anyway, we just wanted to include you in our little farewell gathering. Thanks for helping Charlie out when he arrives." There was a tear in Helmut's eye when he said that.

"Yes, thanks," added Clara. "Bye."

"See you soon," added Charles, and the image faded away.

"When does he get here?" asked Sebastian.

"Next September," replied Kristoff. "Six months to Lutetia, three months on Lutetia, six months to Mars." He hit reply. "Thanks to all three of you, and give Oskar a kiss for us as well. You don't need to give Charlie a kiss for us; he's too big for that, and pretty soon we'll be kissing him for you instead! Don't worry, we'll advise and support him. I'm sure he'll do fine here; he knows this place already, after all, and he's already done so well at Martech. He'll be back in space in six years with a Master's degree in who knows what specialty, and who knows where he'll be off to! Maybe even Ceres!"

"We're looking forward to having him with us," added Sebastian. "Say, I'm curious to know whether anyone up there is discussing the anonymous editorial that appeared in *Mars This Sol* yestersol. The one about Mars extending 'special borough'

status to extra-Martian settlements, which would grant them a non-voting seat on the Mars Council and certain undefined financial supports in return for adopting Martian legal standards. I was talking to Kurt Hollingworth last night and he said he was pretty sure Will Elliott wrote it, which explains why it was anonymous. It seems like a perfect arrangement for Ceres, and maybe Magellan and Mercury as well. Of course, the Mars Council would have to approve it, and possibly the Constitution would require modification. I'm curious about your thoughts about it. Bye."

"Bye," added Irma and Kristoff, and Kristoff pushed the send button. The message was on its way to Ceres, almost an hour away at the speed of light. When it arrived, Helmut and Clara were giving Charles a final round of hugs at the entrance to the *Wolf* itself, so they had no time to watch it. They were part of the small crowd who watched the ship close its main hatch, and then retreated back to the *Piazzi* while crew members in space suits detached and removed the airtight plastic tunnel that had made the *Wolf* a part of Central Station for six months. Helmut and Clara stood in the transparent tunnel under the *Piazzi* and watched the operation.

"He's on his way to Mars, my dear," said Helmut, with a lump in his throat.

"He's left the nest," she said tearfully. It was a moment before she was able to continue. "I hope Kristoff can give him better advice than he could have fifteen years ago."

"He's married and has a family; he's not a lady's man any more." Helmut paused. "But I suspect Charlie will be for a while, so maybe Kristoff's the perfect man to advise him."

“I hope so. Your father will be involved as well, but he’s eighty years old now. Charlie will be at least three years younger than anyone else, other than the other Marsian kids of course, and that’s a small group. That worries me a lot, if the singles scene was anything like it was eighteen years ago!”

“It’s probably even bigger now.”

“I wonder when we should go back,” she exclaimed. “In seven years, Oskar will be ready for university as well.”

“Maybe we should go back to Mars then, at least for a while,” replied Helmut. “We could always come back here later. If we get some fast flights, it’d be feasible to go back and forth.” He pulled out his communicator and saw the message from Kristoff’s, so he played it. Clara looked over his shoulder and watched as well.

“What editorial?” asked Clara.

“I don’t know. We’ll have to go find it. Some sort of permanent relationship with Mars would be good. Every single one of us is a Marsian citizen and every flight to and from here has involved Mars.”

“I wonder what sort of commitment Mars could make. The Commission is working on getting us a galleon and a permanent increase in residents.”

“But we aren’t Jupiter or Saturn, so it’s hard to justify 300 of us here. We do have PGMs, though, the deep drilling project is still yielding good science, and we can do some work with other objects in the Belt, especially if we get another caravel or two. It’d have to be a permanent commitment to expansion and not just a static one to, say, a galleon here.”

“Yes, I agree. Let’s go home and look up the article. We still have an hour before we have to get to work.”

10.

Ice Crystal Cavern

July 2072

“Thanks so much for your help, Cecie,” said Molly, opening the door of her new condo.

“I really don’t know how I would have figured out that purchase!”

“Things are complicated up here, sometimes,” agreed Cecie Tobin. She entered the living room and stood out of the way so that the robotic cart could enter with Molly’s new table and chairs. “We don’t have the people to run stores, so you have to know how to use the electronic help. It’s not too bad, though, once you adjust. I was confused for about a year!” She looked at the cart. “It needs to know where to put the table and chairs. It can set up the table, too.”

“Oh, okay.” Molly walked across the room. “I want the table right here,” she said, drawing a circle in the air. “And I want the four chairs all the way around it.”

“I understand, m’am,” replied the cart. It drove over to where Molly stood and waited for her to get out of the way. Then its two strong robotic arms picked up the table, stood it on the floor, and deployed its four legs, then stood it up. It did the same with the four chairs.

“Very nice, thank you.”

“Have a good sol, m’am,” replied the cart. It folded its arms out of the way and headed out of the condo; it even closed the door behind itself. Molly watched it go, amazed.

“Anything can be delivered here. Let’s sit it down and rest our feet. Tea?”

“Sure, that’d be nice.” Cecie sat at the table and looked around the unit, which had a very large living room with a built in kitchenette and a bedroom in back. “How long have you had this place?”

“A month, but I didn’t get a bed until last week, so I was still staying at Will’s. Too many things to do. The interfaith committee has asked me to serve as acting director because we’ve never had a director; no one had the time. So now I’m doing that twenty hours a week!”

“And the study circles.”

“Yes, I’m running three Bahá’í study circles. Can you make it, morrowsol night? We’re doing Book One.”

“Yes, I told George I was going. I’m adjusting to the Bahá’í idea of revelation. I don’t think I accept Tree Rivers’ conception anymore.”

“How does he understand revelation?”

“He says that Mother Earth or Father Mars are personifications of the life force that works through everything. They can inspire ideas in his head; that’s how his inspiration works.”

“Interesting.” Molly sat at her new table, and momentarily smiled, pleased at her purchase. “I won’t say people can’t get inspiration through nature because I think it is obvious that sometimes, all of us do. Beauty and grandeur can inspire us, for example. But Bahá’u’lláh claims something different. He says that the Primal Will—the will of God, which created the world—can inspire Him directly, and knowledge that He needs appears before His face in written form. That’s how he wrote his letters and books, all six million words of them.”

“Interesting. I really don’t know what to make of Tree Rivers. I have a great respect for him and I think he has some very creative ideas. But he clearly has made mistakes, as the dome leak, not long after he arrived, shows. I’m glad they don’t need me anymore; I have my life here with George.”

“And a baby coming! I’ll be glad to help, remember. The Green World community is a remarkable group, I think, and their emphasis on the environment and nature is laudable; sea level is rising a meter on Earth by 2100 because of the lack of such consciousness there. I would like to see more personal development, though. We are each a mine filled with spiritual gems that spiritual education can develop. We are here to develop our spiritual qualities; our love, compassion, wisdom, helpfulness, mindfulness, fairness, patience, and many more. Those are the things we take with us to the next world, not a condo or a fancy title or the knowledge I was selected to settle another planet.”

A beep came from the kitchen. “Ah, the tea’s ready.” Molly rose and walked to the counter. She opened the valve on top of the pressurized boiler to let excess steam out while she carried it to the table, where she poured two cups of tea. “I’m still not used to pouring water while it’s boiling like crazy!”

“And when it finishes boiling, it isn’t all that hot, but at least the tea has steeped nicely,” said Cecie. She added sugar and took a sip. “I agree with you, the Green World community focuses on achieving material goals—expanding its enclosures and its agricultural exports—more than on personal spiritual development. I’m impressed by the Bahá’í approach.”

“It has worked for me for seventy-two years,” replied Molly. “So, when are you due? Late August?”

“Yes; seven more weeks. It’s a boy; we’ve calling him Lawrence. The Ambassador has given me an extra two months of maternity leave, too, so I’ll have a lot of time to adjust.”

“It’s a big change, but it’s a good one. I will keep all three of you in my prayers.”

“Thanks. The baby has a genetic predisposition toward several cancers that are common up here, so we’ll have to monitor him carefully.”

“That’s always a worry, but it appears life expectancy is longer here, anyway. And how we live our lives is the key issue. It’s easy to forget that on any planet.”

“Is it safe to touch?” asked Ryoko.

“It should be; it’s 25 below in here. That won’t damage your skin if you’re quick,” replied Marshall. Ryoko nodded and carefully picked up a colorful bit of Titanian crust. She admired the streaks of colored ice, formed from mineral impurities.

“The colors are much more vivid here than in the wall itself.”

“The wall of the cavern is covered by white condensation.”

“And it’s perfectly safe in here?”

Marshall nodded. “The air pressure in here is slightly higher than Titan normal. Over the last few months, water and carbon dioxide from the air in here have diffused into the bedrock and frozen the cracks shut. Methane can’t get in.”

“So, we can now build ‘open ground.’ No more plastic bubbles.”

“No more plastic bubbles,” agreed Marshall. “But heating these spaces will be quite a challenge.”

Ryoko shivered. She pointed to the tent and they headed back inside. “I hope you geologists can cut some blocks of the really pretty tholinstone and haul them here to build walls out of them.”

“Perhaps we can. But at 25 below, the blocks will flow and deform very slowly over time, and they’ll get covered with condensation. If we want to retain really pretty cavern walls, we have to keep them away from the water and CO₂ in our breath.”

“No more open ground,” said Ryoko, disappointed.

“Titan is fundamentally too cold for us to interact directly with it for very long,” replied Marshall, shrugging. “I think we’ll have to stick to your simulated tholinstone.”

They headed for the buffet tables. The tent had been erected in N-7, the seventh cavern they had melted on the north side of Acheron’s main corridor. Electric heaters glowed orange to keep the temperature inside reasonably comfortable, but some people—especially some kids—were unhappy. The plastic floor was cold, too. Marshall and Ryoko got their supper quickly and sat with their families.

“So, you showed her the cavern?” asked Amy.

“Yes, and she was pleased. Go take a look when you want seconds; I can stay here with Willie.”

“I will. I looked earlier, too. It is nice to have a place where we can actually touch Titan, without our fingers getting freezer burn. The big, flat floor is convenient, too.”

“Yes; easier to build in than a cavern with a circular shape.”

“Hey Sridhar, how big could we make these caves?” asked Soo, raising her voice so their chief architect could hear her at the next table.

He looked up. “I don’t know, but we aren’t close to the limit. We need about twenty meters of snow and ice overhead for insulation, but in this low gravity it won’t take much metal rebar to support itself. Caverns at least fifty meters wide should be possible. They could easily be fifty meters tall, and there’s no limit to their length, except our ability to heat them.”

“But we’ll still need the bubbles for some caverns, right?” asked Guangya.

“Any space with plants will need a ceiling to separate the warmth they need from the cold roof. That could be any structure.”

Soo and Guangya nodded. She turned to Marshall. “So, you’re heading for the rings with Johnny in September?”

Marshall nodded. “I got permission from the boss, and we’re here to explore all the moons, not just Titan.”

“It’s a three-month mission,” said Amy. “I can handle that. I just hope the proposed trajectory can get the caravels in and out safely.”

“We’ll arrive and depart out of the plane of the rings, where there’s very little debris,” said Marshall. “The ring moons are quite distinctive, geologically, and they’ll tell us more about the evolution of the rings. It should be a very useful and interesting mission.”

“And plenty safe enough; it passed review,” added Guangya. “And you’re taking androids?”

“Now that the *Cassini* is on the way with sixteen more androids and sixteen Prospectors, we can take our old ones here on Titan and deploy them elsewhere. All the moons will be visited every few years to maintain equipment and slowly build up our facilities on them. In a few decades, who knows, there may even be semi-permanent outposts on many of them. There’s a lot to learn.”

“There is,” agreed Soo.

Just then, Yuri rose and clinked his fork against his glass. “May I have your attention, please!” he said. He paused for conversations to die down; most of the population was there. “We have been on Titan one year and ten months, now. Today’s not an anniversary, but N-7 was finished and rated safe, so I thought we should come celebrate its completion together. This cavern—it’s not a bubble—is the wave of the future. We are now free from 75 by 33 meter spaces. In a way, it’s none too soon, because *Cassini* is bringing 120 people, but now only 45 plan to leave, so Titan will grow to 375 adults and 110 children; we’ll be very close to 500! It’ll stretch the capacity of the two galleons, but we can stuff that many more people into them. The expanded crew will allow a larger Department of Domestic Fabrication—the folks that make everything from Barbie toys to bathroom tissue to wedding gowns—which will also make our life better. We will maintain this cavern for recreational space; among the suggestions have been a golf range, a basketball court, and a soccer field. It’s almost big enough for soccer, so we may use it for that purpose until we can melt a standard size field! It’s not too cold if you’re running around, too! Sridhar has an announcement about S-3.”

Sridhar rose. “Thanks, Yuri. You all may recall that S-3 is a bubble with a park level—we’ll be installing cottages there in October—and two levels of agriculture and

work underneath. The lower nine meters of the bubble are empty currently. Starting in January, we'll be installing a nickel-steel floor that will allow us to create a pond twenty meters wide, seventy-five meters long, and up to five meters deep. There will be a shallow wading area for the kids, an area of marsh, and there will be a wave maker so we can conduct experiments on waves in one half of the pond. Eventually it'll have several species of fish—right now all we have is tilapia, but we'll import more in 2074—and over the next few years we expect it to be producing several tonnes of fish and other foods for us per year. It'll also make Acheron a much more interesting, pleasant, and enjoyable place to live.”

He sat and everyone applauded. “Great idea!” exclaimed Shiyoko Takashima, one of their pilots.

“So, will we be able to body surf in the waves?” asked Chad Sutton, smiling.

“Yes, when you geologists aren't using the surf to study sand movement!” replied Sridhar, and everyone laughed. “The marsh will also experience a sort of tide, with the water level going up and down every few hours. Ecology has to figure out what species they want to import in 2074 and how they want to set it up. I'm told ecology already has quite a few species they can use to build a marsh. It's amazing what we have here.” He looked back to Yuri.

“Johnny, do you want to say anything about the mission launching in seven weeks?”

“Sure.” Johnny Lind rose. “We're going to Pan, Prometheus, and Janus. We have a preliminary model for how they fit together originally, before the original body broke up to make the rings, and we're going to them to test the model. We also have to make a

stop to repair one of our Saturn weather satellites, and we're scheduled to deploy our last Saturn atmospheric probe. We might as well use it up! The *Cassini's* bringing us two new Saturn atmospheric balloons, after all. We've got a great crew and we should have a great expedition."

"Thanks," said Yuri. "Teresa, what's new in surface exploration?"

Teresa Alvaro rose. "We have five more eight-day expeditions scheduled all over Titan, then the caravels leave for the rings and we'll concentrate on writing up what we've found, making a series of short local expeditions, and continue exploration via android. We've collecting some really interesting seismic data about Titan's core and we'll be publishing a new model of the silicate mantle and nickel-iron core in a few months."

"That's an important development. Sridhar, anything else to tell folks?"

Sridhar rose. "We're almost finished with the cottages in S-2; people will be able to move in by mid September. S-3 will take two months, then we'll focus on S-4. So far, everyone seems pretty happy with their places."

There was a murmur and people were nodding; the cottages were indeed very popular. Yuri turned to Ryoko. "Any report from our social secretary?" He said that with a smile; it had become their store keeper's informal responsibility.

Ryoko rose. "We have the wedding of Chad Sutton and Rose Chen coming up next weekend and they have invited everyone." Ryoko began to clap, so everyone followed. Chad and Rose—who was pregnant—stood and acknowledged the applause. "The food at the reception will be our regular evening meal. And Toru and Miyumi will celebrate their eighteenth wedding anniversary on Wednesday. Quite an

accomplishment.” More applause. “Next time we gather in a month or so, if all goes well, we’ll be celebrating a birth. Daichi and I want to thank everyone for their warm encouragement since we confirmed we plan to stay a while. Our son has applied for the 2074 flight, so we hope to see our family reunited here.”

There was applause for that announcement, too; many people missed relatives on Earth or Mars. “Okay folks, that’s it,” said Yuri. “These monthly dinner meetings seem to be useful, so we’ll schedule another one for early August.”

Sebastian Langlais didn’t put on a pressure suit very often any more; he was 80 years old, after all. But the new designs were so much more comfortable and reliable, his curiosity overcame the inertia of old age. Besides, the snow field was a short walk from Joseph Hall’s airlocks.

The sol before, two crew had attached a hose to one of Aurorae Outpost’s water lines and had sprayed the north-facing slope of Boat Rock with several tens of tonnes of liquid. The water stream had shot high into the sky, some of it immediately evaporated—some of that fell as tiny snowflakes later—and the rest froze into snowflakes and small ice pellets, which coated a one hundred meter by seventy meter section of the slope to the depth of ten centimeters. Now, on Saturisol, dozens of pressure suited bystanders stood and looked. Snow hadn’t fallen at Aurorae for several million years, after all.

Most people were standing downhill of the snow field, watching trickles of water running down the slope. “Look at the bubbling where the soil has been moistened,”

someone noted over the common channel. The ground was indeed bubbling as the peroxides and perchlorates made by ultraviolet light broke down in the presence of water.

“Amazing to see,” added Sebastian. He saw Érico nearby and walked over. “I bet you don’t get outside much any more.”

“Good sol, Sebastian. No, this is the first time I’ve been outside in two months. The position of Saturn Commissioner doesn’t take me out!”

“No, I suppose not. As the oldest human being on Dusty Red, I have no reason to go outside at all. But this is interesting.”

“Yes, and intriguing. They were just measuring; the snow pack has lost two centimeters since yestersol, but only half of that has run off. The rest has evaporated! The atmosphere here is so thirsty.”

“There will be a light frost for many square kilometers of the Aurorae Valley tonight, too. They should check to see whether this amount of water will be enough for the cactars.”

“I’m sure someone will look into that. The outpost has already changed the local climate measurably.”

Sebastian nodded and walked around the snowpack, then stopped to look at a puddle that was accumulating at one spot. Someone was sampling it for microorganisms, terrestrial and Martian. Then his communicator beeped. It was an incoming message from Helmut, who hadn’t called in nearly a week. Sebastian set it on audio only.

“Hi dad. All is well up here. I’m about to lead an expedition to the north pole to study the accumulated snow and dust layers. We’ve been there several times before, but we want to core the accumulation in a different spot because new seismic data suggests

there's a better record there. Clara's fine, and Oskar just finished a summer course about the history of the settlement of Mars and got an A. Isn't it amazing there's now a course for children about that! Charlie called earlier this sol and is a bit bored, which is to be expected on a six-month flight. He needs more duties, I think.

“But I wanted to call you to ask you to do something. The anonymous editorial in *Mars This Sol* about special borough status has generated quite a discussion up here. We are intrigued by the possibility of being an ‘overseas borough,’ a sort of asteroidal Hawaii. I called Kurt Hollingworth and asked him to talk to people about it. I gather Will Elliott wrote the editorial anonymously. But Kurt said he didn't feel comfortable asking Elliott about it because he couldn't confirm that he was the author. Of course, you can talk to Will about someone else's ideas and he'll be glad to give you his opinion anyway! Now I can't call Will, since I asked the Commissioner. Could you give him a call and ask him what he had in mind, or what the next step should be? No one here knows what the proposal would look like in detail, so no one knows whether we should consider it seriously. Thanks. Bye.”

Sebastian sat on a boulder nearby to consider his response, then pushed reply. “Sorry I can't send video; I'm actually outside right now, looking at the patch of snow they made yestersol and watching it melt. Very interesting. I've read the editorial, which isn't very specific because it's a general proposal. There was a buzz about it in the Gallerie for several sols afterward and most people felt it was an interesting idea, but it had its disadvantages to Mars, because it would cost us money. I doubt the Mars Council will pass a generic law; it needs a specific case. So I think some people up there need to turn the idea into a specific proposal for Ceres. I'll talk to a few Council members here.

I'm sure they'd be willing to give you informal advice so that the resulting proposal is something they could submit as a bill to the Council. That's the way to go."

Ambassador Arthur Danforth looked nervous as he entered Will's office. Perhaps it was because he was outnumbered; in addition to Will, Jacquie Collins, Xiaopeng Cai, and Yevgeny Lescov were waiting. He brought NASA's permanent representative on Mars and his assistant, Dr. Jane Kohl, with him and that helped. Perhaps Xiaopeng made him nervous as well.

"Welcome, Mr. Ambassador," said Will, rising as they entered. "We're looking forward to these discussions."

"Thank you." Arthur shook Will's hand and turned to the others.

"I'm sure you already know Yevgeny, Jacquie, and Xiaopeng. Dr. Jane, it's very good to meet you at last. I'm sorry you had to be here four months before we could meet."

"This has become a big place, Chief Minister Will, but I'm pleased to finally meet you." She smiled warmly and they shook hands.

"Please make yourselves comfortable." Will pointed to the conference table.

"Ambassador Arthur, I have your coffee ready the way you like it. Dr. Jane, coffee or tea?"

"I really don't want to put you out, Mr. Chief Minister."

"Not at all; we'll all have beverages to drink. I'm pouring Marjeeling for myself."

"Then I'll have some as well."

“Excellent.” Will poured two cups of Marjeeling tea and a cup of coffee for Arthur, then brought the tray to the table with a bowl of cookies. “If the negotiations run long, there are more cookies. I understand there has been excellent progress lately, though.”

“Yes, I think so,” agreed Arthur. “The war has delayed many of our space projects, but now they have been rescheduled. They included two twin-caravel missions to asteroids in 2073 and 2076, a major expansion of Peary in 2074 to concentrate on Helium-3 mining, expansion of our Martian south polar station in 2076, an additional caravel stationed permanently on Callisto in 2077, additional support for the Saturn project, and an orbiter/lander swarm for the Uranian and Neptunian systems launched in 2077 and 2080 respectively. The Pluto orbiter and lander have been postponed to the mid-2080s, as have probes to Sedna and Eris. These are in addition to redevelopment of the low Earth Orbit industrial park in the 2071-74 timeframe, continued participation in the Venus and Mercury projects, launch of at least two missions to Near-Earth Objects, and launch of several dozen satellites or interplanetary probes to study the Earth and sun, land on a dozen NEOs, and fly by several Kuiper-belt objects.”

“We have tentatively agreed to the reopening of the South Polar Station,” said Jacquie.

“We’ll look into running our asteroid belt missions past Ceres for shore leave and refueling,” said Arthur. “That is a win-win situation because our people can stay out longer and Ceres will get visitors. We can also shift the Uranus swarm to 2076 and use a gaseous core nuke to launch it on a high speed trajectory, so it arrives in 2078. The big question is how to collaborate with you over Jupiter.”

“We’re almost certainly launching a galleon to Callisto in July 2074; twenty-three months from now,” said Will. “It’ll have 150 on board and will more than double the size of the Callisto facility. Under those circumstances, an additional caravel in 2077 will not be much of a contribution. A galleon in 2076 or 2077 would. Even better, a second galleon in 2074 would provide greater safety during the trip and would give the Jupiter project a weight and capacity similar to Saturn’s. Considering the size of the jovian system and the importance of the Galileans, nothing less should be considered.”

“We are always amazed by the speed and scale of your projects,” replied Jane. “NASA cannot mount a mission involving a galleon in less than five or six years. Crew selection and training alone would take three years.”

“NASA could launch a mission in three,” replied Jacquie. “All you need to do is recruit from among American citizens here. They have the skills and certifications already. We’re continually training up here. They could fly to earth next year, or your galleon could stop here to pick them up.”

“I think it would make more sense for us to launch a second galleon from Earth in 2076,” replied Arthur. “We could support your galleon in 2074—perhaps provide a third of the crew—and you could support ours then. Callisto will expand more systematically and gradually. You can choose the captain of your galleon and we could choose the captain of ours. No doubt China and maybe other nations will be stimulated to add other galleons in later years and Callisto could expand to three or four of them by 2080, able to accommodate 450 to 600 residents.”

“Alright,” said Will. “What about Uranus in 2080? We’d like to send a fleet from here, or two fleets, one from here and one from Earth. We’ve already started on an

exploration plan for the system involving an underground outpost on Titania, robotic bases on a dozen of the other moons that are visited by crew regularly, and ongoing exploration of the Uranian atmosphere with balloon probes. The settlement will involve a minimum of two galleons and 300 people.”

“We’ll want to be involved in that project,” replied Danforth. “Most likely, we’ll want to provide an entire galleon and 150 crew, with an American commander who will be in the rotation for overall system commander, just like the arrangements in the Jupiter system.”

“But let me ask you this,” replied Will. “Do you feel that system really works? Titan provides a better model, where the overall operation has one commander during the flight out and the commander subsequently is elected by the crew after arrival. Titan has a Russian, an Indian, and an American in the command structure.”

“And I suppose when your galleon arrives at Callisto, it’ll do the same?” asked Danforth.

Will nodded. “Of course, and that will put the commanders of the Chinese and American caravels already there in a funny position. We also plan to excavate a large underground complex at Callisto; our galleon will have a construction crew. Right now, neither caravel has the space to host the other for a meal. Our Callisto outpost will have at least five underground tunnels with H-75s, like Acheron Outpost. It’ll have parks, a big recreational space, and a big banquet space. We also have begun to spend a billion redbacks on Earth over the next two years to purchase more androids and prospectors, and New Hanford has started making two dozen RTGs to power them. We have also started assembling bases for deployment on Ganymede, Europa, and Io where robots can

be repaired robotically. We want to see the remote presence of humans on those moons to expand considerably.”

“I bet the Chinese won’t be pleased by your plans.”

“They already aren’t,” replied Xiaopeng. “As our plans advance, they will all go up on a website, so anyone can see them.”

“The purpose of exploration and science are exactly that: exploration and science,” said Will. “They can make jobs too, and bring prestige, too, but those are not the ultimate purpose. When jobs and prestige become the ultimate purpose, exploration suffers. We’ve seen that many times in the last century. Mars has been successful because it focuses on what goal to set and strives to achieve it simply. That’s why we can do several times as much as NASA, per redback spent. Each galleon launched to Jupiter, Saturn, or Uranus will cost a billion redbacks to build and another half billion for crew selection and training and purchase of the necessary equipment.”

“No, we can’t do it for that,” agreed Jane.

“You could, if you contracted with us,” replied Jacquie.

“We don’t want others to stop spending on space exploration; if anything, we want more people spending more,” added Will. “Earth gets richer all the time. If the Chinese don’t like it if we send a galleon, they can purchase one and fly it to Callisto as well, and can subcontract with our crew for additional underground caverns or melt their own.”

“But that’s the issue, Chief Minister Will,” replied Arthur. “Mars is in charge of all this and you want others to partner with you. Well, we want *you* to partner with *us*!

The United States is still the most powerful nation on Earth. It explores space to boost national prestige; that's the main reason we do it. That's true of the Chinese as well."

"No, I'm not saying we have to be in charge; just if no one partners with us, we'll do it anyway, but at a slower pace. We now have eleven thousand people here and in two years we'll have sixteen thousand. In four years we'll have over twenty thousand. We have the base of skilled workers and the equipment to do it ourselves. Over a half century ago, Falcon rockets were manufactured and flown with just a thousand workers! We can do the same with our more powerful machinery, which we had to import over the last few years because of the danger we'd be cut off because of the Earth's stupid wars. We have space technology engineers of all sorts begging to emigrate here with their families because they know our commitment is steady. Next columbiad we'll have the lift capacity to import a lot of them. If you want to keep those engineers and maintain your leadership in space, you need not just money: you need a focused plan. That's what we have."

"And our plan has obvious gaps that you can fill," said Jacquie. "Our gaseous core nuclear engines have a specific impulse of 2,500; just five times better than chemical and a bit more than twice better than solid core nuclear. Uranus will require a lot of hydrogen propellant to send a crew there in two years. Neptune needs better propulsion; either hotter gaseous core engines or advanced ion thrusters. VASIMR claims a theoretical maximum specific impulse of 30,000 and we now have the megawatt space reactors to power it. In ten years, partnering with our New Hanford facility, the U.S. could develop the better engines needed for Neptune and beyond. "

"Or China could do it," added Xiaopeng.

Arthur scowled at Xiaopeng. Will added, “We don’t have anyone doing ion engine development here; not yet, anyway. If we imported a hundred engineers, set them up here and on Deimos, and issued hundred-million redback support contracts to various Earth facilities, we could develop an advanced nuclear electric propulsion system in less than ten years. That’s something we could consider in 2076 when our economic base expands to about twenty thousand people. But if the U.S. did it in their facilities and in Earth orbit or at Peary, it’d provide the propulsion to open up the outer solar system, and we’d probably buy some of the engines for traffic between the Earth and Mars.”

“We also could use outside help to develop the successor to the galleon,” added Jacquie. “We’ll soon need even larger vehicles for immigration purposes. We’re looking at designs with more than twice the interior volume of the galleon, which means each one could carry 300 to Neptune. But the design costs could be well over ten billion redbacks.”

“Again, you’re calling for partnership,” pointed out Jane.

“And you think Congress will fund an independent project?” asked Will. “Do you want to duplicate our Deimos facility in low Earth orbit? Even if NASA contracted the project out, it’d cost you twice as much as it’d cost us, because we have the experienced people from the caravel and galleon projects, and we have all the manufacturing specialists from those projects to help implement the new vehicle.” Will shrugged; Arthur shook his head.

“And you’re talking to the Chinese?” he asked.

“We’re talking to everyone,” replied Will. “We’re briefing Ambassador Mariella morrowsol and Ambassador Shiva next week. Our diplomatic team has appointments in a dozen nations over the next few months. Frankly, Ambassador Arthur, we’re looking at a

whole new approach to solar system settlement. It isn't just exploration; it's settlement. In that new approach, there are no national outposts and national expeditions. Everything is multinational. The residents in each planetary system determine their future direction within the financial parameters their Commissions set. We may even find that Commissions are not the best mechanism, either; that could change as well. The goal is to create settlements large enough to be reasonably self-sustaining, with round trip transportation times short enough so people can go to one planet for a decade, then to their home planet for a decade or two, then back, or to another world for another decade. The role of nations is specialized; they provide technology, staff, and financial support. Their prestige flows from cooperation and support, not from independent achievement."

"That's a big change to engineer, I'm afraid."

"It is, but it's already the wave of the future with Saturn and Ceres, and the alternative isn't working so well on Jupiter. Mercury proved that the old top-down approach had limitations. Scientists are people; most of them want to fuse their work and their family life. They need love as well as scientific challenges. That means they need communities, and the communities need stability, not political fights over who is in charge. This is the solution."

Arthur looked skeptical. "I'll take your message to Washington."

"Please do." They all rose and shook hands again, then Arthur and Jane left. Will sat again and looked at the others. "This won't be easy."

"If they refuse to cooperate, we can still move forward with Europe and India," said Jacquie. "They'll support our approach, as will most Latin American nations."

"So far, China is holding out," added Xiaopeng.

“We need more persuasion,” said Will. “I doubt I can raise this matter with the President; that would be short-circuiting the usual channels and might backfire. But Brian Stark has a lot of contacts. So does former Ambassador Manning. What if I asked them to join the team?”

Jacquie nodded. “I can work with both of them.”

“Good, maybe they can help.”

11.

Difficult Decisions

early Sept. 2072

“The plans for the nineteenth columbiad are a disaster,” began Yevgeny. Henry Smith and Yuki Tajima nodded vigorously; Emily Scoville-Rahmani nodded slightly.

“It can’t be that bad,” replied Will, shifting in his chair nervously. “Last month, things looked fine. What’s different? Has recruitment fallen off?”

“No, it’s as strong as ever; we have 445,000 applications for 4,000 berths, and they’re still coming in,” replied Yevgeny. “We just added one hundred more staff to sift through the applications and they’ll do fine once we are sure of the selection criteria to apply. That’s one problem; well, let me start with the Earth problems and work my way up to the Mars problems. We can’t launch everything and everyone by next fall, at the current rate. The largest passenger shuttle carries seventy-five people, so fifty-five launches will be needed to get everyone to orbit. We’ll have Parenago and Peary full by next month, so we can’t send anyone else to the moon, and the folks there will have to stay there an entire year, which is a long time even with access to Parenago’s centrifugal gravity. We’ll have to rotate the Peary personnel down to Parenago every six months for their health, which causes all sorts of training and work problems; but those are the least of our problems. Everyone else will have to be accommodated on the galleons, but of course they won’t arrive until January, when they arrive via Mercury. So we’ll have to stop launching people next month for three months because there’s no place for them to go. We had planned to stuff the galleons with a thousand people each because the flight to

Mars would be only forty days, but now most of those people will have to stay on board up to nine months before trans-Mars injection, so that plan won't work."

"Can we send more vehicles?" asked Will.

"We'll have to send every caravel we can; probably six. We'd send them back here with a standard load of 155 passengers on a six-month trajectory, thereby reducing the load on the galleons. But getting all the propellant is problematic. Each galleon will mass about a thousand tonnes. A high-velocity launch of the sort approved for Saturn and Jupiter—which will get the galleon here in forty days—requires a total propulsive delta-v of about 30 kilometers per second from the L1 Gateway, which with gaseous core engines will require 1,700 tonnes of liquid hydrogen per vehicle, 6,800 tonnes altogether. We can get about 2,000 tonnes from the moon. If the Prometheus shuttle that is first launched in December can make 50 launches at 55 tonnes each by next autumn—which is optimistic—that gets 2,750 tonnes of liquid hydrogen into low Earth orbit, *not* to Gateway, which will take additional time and use up a quarter of it. We were counting on all the Swift and Boeing shuttles to lift the rest, and maybe they can, but demand for launch to low Earth orbit has shot way up as the new LEO industrial park is built. So most likely we're looking at a 70 to 90 day trip to Mars, extra life support equipment and consumables, and very crowded conditions."

"What about postponing our cargo launches?"

"This includes postponing them. That's a whole other problem because with the large gold surplus, we're buying and importing 4,000 tonnes of stuff. The most efficient way to increase our cargo transport is to load the solar sailers at Gateway and use chemical propulsion to move cargo to Gateway from low Earth orbit. But that pushes up

demand for chemical propellant or liquid hydrogen in low Earth orbit, which competes with the galleons for it. All our problems stem from the decision to scale up from 1,300 immigrants to 4,000 in one columbiad. Normally we increase our level of immigration no more than fifty percent, but in this case we're increasing it by three hundred percent."

"We thought we could do it because if the war hadn't happened, the last columbiad would have seen about 3,000 immigrants and 2074 would have been as high as 5,000," continued Yuki. "But terrestrial infrastructure is still inadequate because of the war, and we are competing for launch space with the rebuilding effort. Everyone's still guarding their own turf and charging us as much as they can. As a result, launch costs are thirty percent higher than expected. Each immigrant will cost a million redbacks. In 2076, with the addition of the Prometheus shuttle, launch capacity will triple and the cost per passenger will drop by at least half, but that doesn't help us this time around."

"And that doesn't even get to the Mars end of the problems," added Emily. "Lately, our total adult population has been growing fifteen or twenty percent per columbiad, but in 2074 it will expand sixty percent. Departments can't plan their hiring very well for such a number. Marbuild can build the enclosures, private firms can build the housing and supply the furniture, and Agmar can feed everyone; we have those needs under control, more or less. But so far, the number of posted job openings total only 2,300."

"Private hiring is being very conservative in particular," added Henry. "People remember their near-bankruptcies of two years ago. We need a program to boost private hiring."

“And clearer guidelines to governmental agencies, Martech, the hospital, and public companies like Marcraft,” added Emily. “The budgets for the 2075-76 annum need to be fleshed out.”

“A very difficult thing to do, because revenue can’t be estimated accurately,” added Yuki.

“And all this gets back to the selection process, because the main criterion for selecting someone for flight, after they’ve cleared the various medical and psychological hurdles, is whether they’ve got a job,” added Yevgeny. “By now, we wanted to have three quarters of the immigrants selected, but we’re barely at forty percent.”

“And you won’t get to one hundred percent if there aren’t enough jobs.” Will leaned back in his chair to think. “We have Earth problems to fix and Mars problems to fix. We had planned to send four galleons here quickly with gaseous core propulsion. Let’s switch from gaseous core to chemical; that increases our propellant supply five or six fold, assuming the oxygen is available at Gateway. Stretch out the transit of the galleons to at least 130 days; they’re rated to accommodate 650 for that period, and with the zero-gee recreational areas we could probably push it up to 700. Accompany them with solar thermal engines so they can decelerate before aerobraking, to increase the safety margin. Send at least one via Mercury and one via Venus with the caravels going on those routes. Make sure we’re using our six caravels, plus the Mercury, Venus, Green World, Lufthansa, and United Spaceways caravels. The Venus and Mercury transits leave Earth much earlier, so that minimizes the number of people we have in Earth orbit or at Gateway at any time. The plan to send four packed galleons high-velocity was unwise; we were seduced by the technology.”

“If we have permission to back away from gaseous core, use chemical propulsion and send the galleons on these other trajectories, that improves the picture,” agreed Yevgeny.

“Just get the people here,” replied Will. “It’ll simplify the logistics at this end, too, if people are arriving over six or seven months. Send as much to Gateway from Phobos as possible, too; propellant, consumables, life support equipment, whatever. We have a year to get things there by solar sailer. We even have three or four solar thermal engines we could use. Phobos has plenty of propellants. Now, in terms of the problems at this end: we probably need to create another 2,500 potential positions, wouldn’t you say? If there are 5,000 possible positions and they are arranged more or less hierarchically, we can accept the 4,000 candidates who have filled the 4,000 best positions. How many potential employers do we have up here? A few hundred?”

“Maximum,” replied Emily. “There are about twenty big employers, including agencies and public companies. The rest might hire one or two at most.”

“The rest are private firms,” agreed Henry. “Some might hire six or eight. With a plan to encourage private firms, maybe more.”

“Then the three of us have a lot to do in the next few weeks,” replied Will, looking at Emily and Henry. “Let’s meet in a few sols and start to rough out how big each one is now and how big they could be, especially to accommodate about six thousand immigrants in 2076. We should hold a big all-day meeting of CEOs of the top twenty or even the top fifty. Let them talk to each other about priorities, ways they can work together—if agency A hires twenty, agency B may need to hire two—let them explore

bottlenecks together, and we'll figure out what we can do to help them. I suspect a meeting like that could generate several thousand job descriptions."

"That would even help shape the twentieth cumbiad," said Henry, nodding.

"We don't have to guarantee everyone a job on arrival, either," noted Emily. "We can give them a few months to adjust to the place."

"True, but I don't want people to think they don't have to work, or that we are disorganized," said Will. "I'd rather implement a plan to hire everyone as quickly and efficiently as possible. We'll all meet again next Monsol afternoon and see how we're doing."

"I think the Ceres Council has met more in the last month than it did in the last six years!" said Dr. Juliette Delafontaine, as they began their business meeting in the rear of the dining room. "But we've made a lot of progress on the 'Extraterritorial Borough Resolution.' Adam, you emailed me with two points. Can you repeat them for everyone?"

"Thank you, Madame Chair," replied Adam. The Lebanese-Marsian chief of the outpost's construction had devoted more time to the declaration than anyone else, sending frequent emails to the other members of the Council during the wee hours of the night. "I think the declaration is pretty clear and ready to submit to an outpost meeting. My concern is about the wording of the extraterritoriality clause and what sort of negotiating position it puts us in."

"With Kurt opposed, we're in a difficult position," replied Helmut, referring to Kurt Hollingworth, the Commissioner of the Asteroid Belt Commission. "Six years ago, the Commission approved all of our charter except the issue of territoriality. That was the

only way the ABC could have approved it. Legally speaking, Ceres belongs to the ABC on behalf of all humankind, not to us residents. So Mars would have to perform an interesting legal dance, to give us borough status.”

“But that’s why we’re an ‘extraterritorial borough,’” replied Rahula Peres. “It’s a borough in terms of people and structures, but not in terms of land.”

“We need to strengthen that clause of the declaration,” said Helmut. “I would add to the wording ‘the residents of Ceres recognize the Asteroid Belt Commission’s possession of the territory of the minor planet Ceres and nothing in this declaration is meant to nullify that possession.’”

“I’d rather say ‘the residents of Ceres recognize *for now* the legal claim of the Asteroid Belt Commission to possession of the territory of the minor planet Ceres and nothing in this declaration is meant to nullify that possession,’” replied Adam. “The declaration should not imply the perpetual jurisdiction of the ABC.”

“Let’s not antagonize them,” replied Helmut. “We have to negotiate with the Commission, after all, and with Mars, which has to consider the Commission’s views. If we said *for now*, that could imply that in the future the borough of Ceres would assert possession of the asteroid, and as Marsian citizens operating under Marsian jurisdiction, they’d be claiming Ceres as part of Mars. That would raise a lot of concerns.”

“But where does our future lie?” asked Jack Alberghini. “I’m not planning to stay here forever. I’m 49; I suppose in ten years I’ll go back to Mars, work another decade there, and retire. Most of us are tied to Mars and plan to return there, unless our children have gone to another world. Why shouldn’t Ceres be a part of Mars?”

“Think of it this way, Jack,” replied Adam. “If you are living in Rome, the city of Rome has one kind of legal jurisdiction over you; you have to pay them property taxes, for example, and pay their parking tickets. Italy has another kind of legal jurisdiction over you. So that piece of land has two legal jurisdictions coexisting on it. Ceres can be the same way.”

“But in this case we’re talking about three jurisdictions,” said Juliette. “So it’s a bit more complicated. If we recognize the jurisdiction of Mars’s laws here, if we ever have a murder, Mars, not the ABC, would have jurisdiction.”

“Then let me clarify my example,” replied Adam. “Because the European Union also has a layer of jurisdiction over the land of the city of Rome. Three legal jurisdictions can coexist on the same territory. The ABC can’t adjudicate a murder case anyway. The ABC treaty specifies that the laws of the national sovereignty where it is seated apply, and it is seated in Aurorae, so Marsian law already applies to murder cases here.”

“Let’s hope the ABC headquarters never moves to Earth!” exclaimed Helmut, and they all chuckled at that.

“So, shall we add Helmut’s wording to the declaration?” asked Juliette. She read it aloud again and everyone nodded, so she inserted it into the text, which was visible on a wall screen.

“My other question—it wasn’t a proposal for rewording—has to do with the old bugbear of self-sufficiency,” said Adam. “I’d rather that we approach Mars from a position of relative strength. During the first two years here, we figured out how to extract PGMs from ataxite in a low-gravity environment. It wasn’t as efficient as anyone hoped, but we covered maybe half of our expenses. During the war, we stopped PGM

extraction because there was no market for it. Meanwhile, the Uzboi engineers have made the process even more energy efficient. With new PGM extraction equipment and additional solar power—Mars can make panels pretty inexpensively now—I think we could probably cover our routine expenses; salaries, equipment imports, passenger flights, etc. But it would require several hundred million redbacks in the form of a grant or loan.”

The others said nothing at first, considering the implications of Adam’s idea. “Raising this issue now has disadvantages,” said Helmut. “We don’t want to look like we are going around the ABC for funding and we don’t want to look like we want to be a borough of Mars in order to get money. I think we should restart PGM extraction, though. We need the nickel-steel for casings in the deep drilling project anyway, assuming we can figure out how to push even deeper. The prices of PGMs have returned to their pre-war levels; a lot lower than gold, but still sufficient to make a profit.”

“Funding all the expansion projects that have been proposed is a huge problem, and it’s not clear Mars is a better source than the ABC,” said Jack. “Mars is providing half the funding for the ABC, anyway.”

“And that would continue,” said Helmut. “If you follow *Mars This Sol*, you can see the policy Mars is pursuing quite clearly: aggressive expansion into the solar system, but with as many terrestrial partners as possible. They’re talking about getting us a galleon or two, expanding our population to as much as 300, adding more surface structures, developing our refueling facilities so that caravels visiting the asteroid belt would stop here regularly, etc. We’ll need large hydrogen storage facilities for the nuclear

engines. That probably means a nuclear reactor, too, not more solar. If we're an extra-territorial borough, that commitment will probably increase, not decrease."

"And they'd funnel the money through the ABC?" asked Jack.

Helmut nodded. "I hope so. That's what I would aim for, because we want the terrestrial partnerships and funding to continue."

"That would continue the ABC's role, also," said Juliette. "It would be like a Board of Trustees, overseeing development plans and arranging for their funding."

"Something every borough on Mars could use," added Adam.

"Let's finish this up," said Juliette. "The outpost meeting to discuss it is next Monsol."

Brian Stark had lost weight. "You look really fit, Brian," said Will, as he welcomed Brian to his office with a handshake. "Marabica?"

"Sure. Yes, if anything I'm a bit underweight; I've been doing a lot of running and haven't made up for it with more calories."

"Where, around the Outpost?"

"Sometimes I'll join the 11 p.m. crowd or the 6 a.m. crowd, when they leave one tunnel door open to make it faster. But I like to go to the Martech fitness center, tilt the treadmill to thirty degrees, and run."

"Wow, that's good exercise. I walk fast on a treadmill; I don't jog much. I like to hike to the top of Baltic South, though."

"I'm not sure I'll be doing much jogging at age 71."

“I’m in pretty good shape, though.” Will walked to the table with a cup of black Marabica coffee and brought his own cup of tea.

“How are you holding up?”

“Pretty well, even though I’m working over twelve hours a sol to make sure the nineteenth columbiad goes smoothly. I’m taking a break from that to meet with you.”

“So, you said in your message ‘your country needs you.’ I wasn’t sure which one you meant!” Brian laughed.

“I meant both of them, but I’m not sure whether more people in Washington view you as a hero or a traitor.”

“It depends on the day. Most people regret the U.S. actions on Mars. So, you want me to lobby for something?”

“I want to hire you as a special representative to the United States for the Ministry of Space Exploration. Last Monsol Jacquie, Xiaopeng, and I met with Ambassador Arthur and Dr. Jane—”

“Jane?”

“Dr. Jane Kohl, assistant to Ambassador Danforth for space exploration. I suppose you’re basically familiar with our space policy?”

“Yes; expand outward and take over as much as possible, if I may put it from the Ambassador’s point of view.”

“I hope you don’t use that phrase with him! We don’t have to spend practically anything on elder care or retirement and we’re spending nothing for defense. Education and health care together are larger in our budget than most nations’s but we still have a significant ‘surplus’ for supporting immigration, technological development, and

settlement of the solar system. We want to see Saturn have two galleons, one going back and forth every two years. We want Jupiter to have a galleon on the surface of Callisto and one going back and forth every two years. We want Uranus to have four galleons; two on Titania and two going back and forth every four years. We want Ceres to have a galleon, in spite of the complication their vote last night has created. We want Venus to have a galleon and probably a collection of small hundred-meter asteroids for radiation shielding and local resources. Saturn has its first galleon; the remaining nine, one per year, will cost us a billion redbacks per year, which is manageable. The cost of propellant, personnel, and equipment is about a billion per year as well, and we'd like to get at least that much from the US, China, Europe, India, Brazil, Japan, Canada, Australia. . . etc. We want the United States to be our principal partner, but they want to be in charge of anything they contribute to."

"Of course."

"We want partnership. We'll agree to American commanders who aren't Marsian citizens, but obviously we want commanders of all backgrounds, and the more countries we add to the partnership, the greater the diversity of the crew and the commanders. American technological innovation is the biggest contribution their money can make; we need efficient, powerful nuclear electric propulsion to reach the outer planets. We're willing to have the voting strength roughly proportional to the financial contributions, too."

"Roughly?"

“We don’t want the Uranus mission saddled with some pie-in-the-sky propulsion boondoggle that costs two hundred billion dollars. We have people who can estimate project costs pretty well.”

Brian nodded. “I understand the problem.” He sighed. “I struggled with the politics of allocation constantly. This Congressman wanted a piece of the project in his district, or he wouldn’t vote yes. Agree to it, and four more Congressmen wanted pieces in their districts as well. It went on and on. And it was usually a losing battle.”

“That’s why, as Commissioner, I closed twenty Commission offices and several major support facilities. I had the advantage of longevity, too; I was in a position of authority long enough so I could wait for the right time.”

“We need specific American support for specific aspects of the project. But to do that, we have to be in charge. And that’s not easy.”

“Can we set the various projects in a larger context? Colorado can’t expect a major contract for ion engines because it’s getting a bioarchive, for example.”

“Yes, and because the Alamogordo Labs have subcontracted something to someone in Denver. We’ll need a big database to keep track of everything. But I think it’s easier to get everyone together and agree what needs to be done, assign each country its share of the project and its voting power, and then hold people’s feet to the fire to make sure they get their part done in time.”

Will nodded. “Yes. A thousand-page treaty and a small army of lawyers is the cheapest way to go.”

“I think so.” Brian sighed. “I’ll make a round of videomails to people in Washington; many of my old friends are back in charge under Mennea.”

“I’d start with Dr. Jane.”

“Yes, I’d like to meet her, too. So, we’ll try a meeting of national representatives?”

“Yes, either here or on Earth, though obviously we’d prefer it to be here. Pete and Ruhullah can handle it if the meeting’s on Earth.”

“I think I’ve seen some of the galleon numbers you mentioned to me in *Mars This Sol*, so that puts us in a strange position; we can’t back away from them and if we are even more generous, we look like we want to take over even more.”

“I think we need to hold this meeting on both worlds simultaneously,” said Will.
“We need to see what’s happening.”

“It’ll take at least a month to set it up, too.” Brian nodded. “Okay, I’ll take the job.”

“Great! Thanks, Brian.” Will rose and they shook hands.

“My old Hanford salary? Seven hundred thousand?”

Will nodded. “Alright. That’s reasonable. Better than the pension you’re getting.”

“And it’ll get me out of the house for things other than jogging and poker games with friends. By the way, did you hear? Skip’s coming back next columbiad.”

“Really? Great, it’s always good to have him here.”

“I’ll go talk to Jackie and Xiaopeng first, right? Then I’ll send the three of you a strategy email, and get started.”

“Good. Thanks again.” They both rose from the table and shook hands, then Will escorted Brian to the door. Huma was waiting and escorted him out of the outer office as

well, then closed the door and turned to Will. “Shall I send an edited transcript to Jacquie and Xiaopeng?”

“Yes, and Yevgeny. The suggestion that we have a miniconference was a good one. I’m not sure why we didn’t think of it.”

“That’s the advantage of consultation, as you like to say.”

“Now I’ve got to turn to the plans for the conference, so hold the calls.”

“I will, but you just received a message from Klaus Richter regarding Mercury. I thought you should watch it.”

“Okay, thanks.” He returned to his desk and reluctantly pushed play. Klaus Richter was both the Commissioner for Mercury and elected commander.

“Good sol, Will. I hope you are weathering the storm well. First I hear the 2074 immigration is being restructured, then I hear Ceres votes to accept the ‘Extraterritorial Borough Declaration’ and see everyone on Earth’s commenting about it, mostly negatively. We have people here already reading the Extraterritorial Borough Resolution with great care and interest, though I doubt there’s serious interest in it; not yet, anyway.

“Interest could develop, however, because about thirty-six hours ago we made a painful and difficult decision: we’re shutting down the Caloris gold mining operation permanently. It’s very hard to support, logistically, it’s extremely expensive, and underground mining is always more expensive than open pit mining; except we can’t easily do open pit mining here, like you can on Mars. When the price of gold skyrocketed during the war it was profitable, but because of our distance from Earth and Mars it wasn’t practical, and now that the supply lines are reliable the price of gold has sagged

too much. This will cause all sorts of second thoughts by the residents and doubts about Mercury's long-term viability by the pundits.

"I'm not taking any position about whether borough status is good for Concord Station or not, though I doubt it'd be workable because of our distance from Mars and the size and potential of this world. But the Mercury Commission could use Mars' help. There are ataxite and enstatite chondrite deposits within two hundred kilometers of Concord. They're large enough to give us a good income stream for several decades. If we produce PGMs, we'll keep all our people here, concentrate resources, cover some of our costs, and recover from the loss of a sense of independence that closing Caloris will produce. I've made a few queries and it would seem that almost all the folks who have worked at Parenago have gone to Mars! If we could import a dozen folks from Uzboi, they could get our equipment set up properly. Thanks for your advice. Bye."

Will hit reply and copied Jacquie and Xiaopeng. "Thanks for the call, Klaus. I'm sure the closure is a shock for some people and a psychological blow to others. I gather just about everyone on Mercury has rotated through Caloris Outpost, and vigorous efforts have been made to develop the place, in spite of the remoteness and extreme conditions. That's not a decision you would make lightly.

"You can be sure we will assist you with this matter, even if it means competition for our PGM production. We'll have no objection if you advertise here for PGM miners, and we'll authorize our PGM Technology Center at Uzboi to cooperate with you fully. The Phobos engineering team may be able to help you develop better sunshades, too. I assume they'll work better at the poles where a small shade will produce a huge shadow and the surrounding land emits less infra-red. I don't think the issue of extra-territorial

boroughs has anything to do with this. If we refused to help you, you wouldn't be competing with our PGM exports, but no one there would be inclined to ask for extra-territorial status either. Demand is such that additional production won't lower the price too much. I have no idea what the Mars Council will do with Ceres's declaration; most members were surprised by it and no one has any opinion about it yet. We'll see. Bye." Will sent the message and immediately Huma stepped inside.

Will groaned. "Now what?"

"Ambassador Zhao Tao called and said he was coming over immediately. I told him he couldn't; you were too busy."

"And I don't want to meet with him unless Jacquie and Xiaopeng are present as well."

"He's on the line, waiting to talk to you briefly."

"I see. He is a real pain, and this is a bad time! Okay, put him through." Will went back to his desk and pushed the activate button as soon as it lit up. "Ambassador Tao, I am not prepared to discuss our negotiations at the moment, so all I can do is listen and record your proposals."

"I'm not calling to negotiate, Chief Minister Will. My government has instructed me to register its concern about the Extraterritoriality Declaration. We do not favor Mars gobbling up the largest object in the asteroid belt. It was brash to write the editorial in *Mars This Sol* and any action to accept the Declaration will have consequences for Mars's relationship with China."

"Mr. Ambassador, the editorial is anonymous and I have no comments about its authorship, which has nothing to do with official Marsian government policy—"

“It’s well known you were the author, sir.”

“I disagree, that is not known at all—”

“Do you deny it?”

“I neither confirm nor deny it on the grounds that if you go around and ask everyone up here whether they wrote the editorial and they say no, and you then ask the author and he or she refuses to answer, his or her anonymity is destroyed. On those grounds, ethically, no one should admit or deny authorship.”

“Never mind about that, then. The jurisdiction of Mars has been well defined in the treaty that led to your independence; it stops 100 kilometers up, plus there’s a 100-kilometer sphere around both moons. Ceres is hundreds of millions of kilometers beyond those boundaries.”

“Mr. Ambassador, it is fascinating to see that the editorial has stirred such a reaction on Ceres, where 72 percent voted in favor of the declaration. The next step is the Mars Council’s; it has to meet and decide whether to consider the Declaration. I have no idea what they will do; do you? The declaration makes it clear that the residents of Ceres can only request borough status without a declaration of sovereignty over territory, so Mars can’t establish a territorial claim over it. We were all caught by surprise by their declaration. I am not aware of anyone who was in communication with the people on Ceres over the proposal; in fact, I doubt Kurt Hollingsworth would be favorable.”

“If the Mars Council approved a bill supporting the declaration, would you sign it?”

“I think we should wait and see what sort of discussion occurs. There may be many serious issues. A Marsian borough on Ceres could cost us a lot of money. The

Asteroid Belt may be like all those little Pacific island nations; perpetually poor and needing assistance.”

“More likely, the Belt will consist of a million uninhabited rocks and a half dozen communities of wealthy miners.”

“Ceres, however, is not the logical place for one of those communities. Its PGM supply is limited. Keeping Ceres going may not be scientifically justifiable; it’s an interesting world, but it’s one of many. The ABC needs to keep its sights on a hundred worlds and not focus on just one.”

“I think that’s true. So, Mars doesn’t have aspirations in the Belt?”

“What do you mean by ‘aspirations’? We want to see human settlements on or orbiting every planet in the solar system. We are dedicated to supporting that goal and supporting those communities. But we do not want to become the ‘Commonwealth of the Solar System.’ We are the ‘Commonwealth of Mars.’ We can’t remain the Commonwealth of Mars with boroughs on Titan, Titania, Triton, Mercury, and Ceres.”

“I will take that position to my government, then.” Tao sounded mollified. “Thank you Mr. Chief Minister.”

“Thank you, Mr. Ambassador. Good bye.”

“Good bye.” Will closed the line and glanced at the electronic paper covering his desk with a sense of dread. The big meeting of employers was just ten sols away, now, and there was a lot to do. He’d have to work extra hours that night to catch up.

When the tunnels' airlock door opened, they were hit in the face with tropical humidity. "Caribbean it is!" exclaimed Molly. "It reminds me of my visit to Guadeloupe or my many days in Santa Cruz, Bolivia, which is in the tropical zone."

"This enclosure is for plants, not for people," replied Mike. "So it is Caribbean in climate, not in name."

"Except for the hurricanes," added Liz, watching Jason and Shayda, who at age two loved to run around.

"Let me take your hand," Ethel said to Shayda, seeing Liz's concern. Shayda loved holding grandma's hand.

"I'll watch him," said Mike, with a smile.

They followed the pathway into the enclosure. Corn blocked their view to the right and sugar cane to the left. As they proceeded the plastic ceiling rose higher and higher. Even the children looked up. When they reached the middle, they stopped by a pylon and looked at the cables streaming down from the dome. "It's like an upside down suspension bridge," said Molly.

"The air pressure is three tonnes per square meter, believe it or not," said Mike. "It's incredible to think that air pressure is that high, but that's less than a third the pressure on the surface of the Earth. In a dome with 210,000 square meters, that's 630,000 tonnes of upward force, so it needs a lot of cables. Even so, the total upward force equals two thirds the mass of the Golden Gate Bridge."

"So much bigger domes are possible," said Ethel. "You sound like Ramesh!"

"He gave a lunchtime lecture about Caribbean and Mediterranean at Martech last week."

“I’m impressed that the sky even looks blue,” said Molly. “Is the dome tinted?”

“Yes,” said Mike. “But not so much near the bottom. If you look at the Escarpment, you can see the sky is reddish. They decided a blue landscape would look strange, so the tinting starts about twenty meters above the ground.”

“And it reduces the ultraviolet?” asked Molly.

“Yes, to about half earth normal; the bees need some to navigate.”

“It’s so big!” said Liz. “When will they build in here?”

“A few years,” said Mike. “Right now, it’s all agricultural. That’s why they haven’t opened it to the public until this sol.”

They kept walking across the enclosure; 300 meters wide, it took a while with the two year olds. At the far side the corn and sugar cane were replaced by wheat and they had a view of the entire space, which ran 700 meters northward from the base of Layercake Mesa. Caribbean North was being cleared and prepared beyond the plastic endcap.

They entered the main tunnel to Mediterranean, which had just been opened to the public that sol as well. It was a 150 meter walk; quite a long way, and the kids got bored, so Mike picked up Jason. “So, Aunt Molly, now that you’ve been here six months, are you enjoying Mars?” Mike asked.

Molly smiled. “I suppose I am! I’ve met all the old timers and they’ve accepted me warmly. It turns out I’m the only person up here with certification in English as a Second Language who has time to use it, so here I am, running English classes every afternoon or evening for spouses whose English needs help. That’s proving a lot of fun.”

“And you’ve been able to invite several people to Bahá’í meetings,” added Ethel.

“Yes, and I’m running several Bahá’í study courses. People say they’re too busy for religion—even the Bahá’is!—but there’s a hunger for spirituality.”

“We’re so grateful you’re here,” said Ethel. “Having people with time to offer Bahá’í classes—even to visit people in hospital—is hugely valuable.”

“I certainly feel useful.” Molly turned to Mike. “How’s your work?”

“The research is going pretty well. And it appears Liz has given me permission to apply for an asteroid mission—not a multi-year mission to the Belt, but a three or four month mission to a Mars-crossing asteroid—and I’ve applied for a mission next year to a nickel-iron body that should have paleomagnetism. So that’s exciting.”

“That is!” said Molly. “Congratulations!”

“He doesn’t want to go to Phobos or Deimos; they don’t have much of a magnetic history, and they’ve been studied,” said Liz. “So he has to go thirty million kilometers.”

“Well, I want to keep up my certifications, and we are a planet of explorers,” replied Mike. “Our understanding of Mars will be enhanced by skills honed through comparative work.”

“We’ll help with Shayda and Jason,” said Ethel. “Don’t worry about that.”

“I’m counting on that,” said Liz. “The new dance and gymnastics program we’ll be starting next year is taking a lot of my time.”

“That, and the new sports program are exciting developments,” said Ethel.

“I really don’t have a sense of what this place was like during the war, though,” said Molly. “People seem partially traumatized by the experience, but they don’t say what it was that was so bad.”

“It wasn’t one thing,” replied Ethel. “We weren’t starving or anything like that. It was a combination of shortages, uncertainty, and worry about relatives on Earth. Everyone’s experience was different.”

They reached the airlock door at the far end of the tunnel and it opened automatically as they approached. Light and warm, dry air poured in. They stepped out of the tunnel and into Mediterranean.

“Wow; even bigger and higher!” said Molly. “And more Mediterranean in humidity!”

“Very pleasant,” agreed Ethel. “But the ground’s still bare.”

“That’ll take another year,” said Mike. “This place is a half kilometer wide and 800 meters long, with two lines of pylons down the middle; you can see the three arcs of cables. It can feed 2,300 people; half the 2074 arrivals. It increases our polder by a quarter, to 1.3 square kilometers.” He pointed up. “The center is 250 meters high. It’s so high, it goes up the side of Layercake Mesa to the top without any problem. Ramesh said we could set off fireworks in here!”

They laughed at that. “I wouldn’t want them to hit any of the cables,” said Molly.

“And there’s a public transportation tunnel underneath, right?” said Ethel.

“Because it’s a long walk back to Andalus from here!”

“The Outpost is now almost three kilometers long,” agreed Mike. He pointed to a crowd of people by a building. “It’s right in front of us. That’s the future village center. This place is going to have Greek and Turkish architecture. The buildings don’t have to include airtight bubbles, either, because the dome is so big, the air can’t leak out very fast.”

“This would be a pleasant place to live, I think,” said Ethel.

They let the kids run off the paved road and run around on the bare dirt of the huge space as they continued to stroll forward to the middle of the space. It almost felt like they were outside. A half kilometer wide! “Do you realize that this is twelve times wider and twenty times longer than our first biomes?” said Ethel.

Liz nodded. “Good old Yalta. And it seemed so big to me, as a kid!”

As they approached the building and a sign that said “The Agora,” they realized that the building sold ice cream. That explained the crowd, and was too much temptation for them, so they got in line. Once they had their cones, Mike pointed to a man and woman nearby with a circle around them. “There’s Ramesh.”

“Soaking up the accolades,” said Ethel.

“He should, this is worth accolades!” replied Mike. He led them over and they stood listening.

“Good sol, Ethel!” said Ramesh. “How are you! Welcome to Mediterranean!”

“Thanks, Ramesh, and congratulations on the magnificent work,” she replied.

“We are very impressed.”

“Thank you, the dome has been nominated for a major architectural award.” He shook hands with Ethel. “Is this Molly, your sister in law?”

“Indeed.”

“Pleased to meet you, Molly. I was so shocked by the arson attempt against you. I’m glad you made it here safely.”

“Thank you, Ramesh. I’m pleased to meet you. We are in your debt for this marvelous space.”

“Thank you. Liz, Mike, it’s good to see you again as well.” He shook their hands.
“And these are your kids?”

“Jason and Shayda,” replied Liz.

“Marvelous. Let me introduce my new wife, Crystal.”

“Very pleased to meet you,” said Ethel, smiling. “Congratulations, I heard about the wedding; it was just two months ago, right?”

“Sixty-three days,” replied Ramesh.

“So, what’s the next project?” asked Mike.

“We’re busy building Caribbean South here at Aurorae, plus Cassini 6 at that outpost, a 300 by 500 that will increase its polder four fold. That’s huge. Tithonium will get a 300 by 300 meter enclosure in 2075. West of Mediterranean we’ll build Caspian, then Atlantic, and then Pacific, which I hope will be 1.5 to 2 kilometers wide and 2 kilometers long. We’ll see. In there, you’ll have up to a kilometer of air overhead, massing half a tonne on average; pretty good shielding against cosmic radiation! After that, I suppose we’ll name the enclosures after continents, in order of their size.”

“That’s quite a plan,” said Mike. “How big and high can you make an enclosure?”

Ramesh shrugged. “With multiple lines of central pylons, they can be infinitely wide. After this, we’ll no longer leave wide strips of range land. The enclosures will be one hundred meters apart.” He turned to Ethel. “You must be so proud of Marshall.”

“Yes, we are. We’re all gathering this evening to watch the landing and first EVA on Pan.”

“All of Mars will be tuning in. The shots of the rings have been absolutely amazing. So, Mike, do you wish you were going?”

Mike was startled by the comment. “No. As a geophysicist, I study magnetism. Saturn interests me, but Pan wouldn’t.”

“Ah, I see.” Ramesh looked around. “So, Will didn’t come with you?”

“No, he’s hard at work.”

“On Sunsol afternoon! That’s too bad. But the immigration plans and the solar system summit . . . that’s a lot to deal with, right now.”

“Too much,” replied Ethel. “Believe me, it’s too much.”

The electric bell in the campanile of the Commonwealth building was chiming 12 midnight when Ethel crossed Andalus Square on her way home. When she came into the bedroom area, she found Will at his computer, recording thank-you emails.

“Are you still up? It’s 24:03.”

He looked up from the screen. “I know, but I’m almost finished. I counted thirty-three tasks from the employment summit and I’ve completed thirty-one of them.”

“Well, come to bed pretty soon, you need your sleep, too.”

“How was bridge?”

“Molly is a better player than you are. Roger and Madhu wondered where you were and nodded understandingly when I said you weren’t socializing with anyone recently, including me.”

“Well, I think the worst is over.”

“You looked shocked when the gold mining companies together announced they wanted to fill two thousand positions.”

“I was shocked and angry! They hadn’t indicated a need for such a huge expansion before. Frankly, I don’t believe gold production is about to plunge suddenly at four outposts at once. Their requests were quite unreasonable.”

“I thought so, too. I suppose that means you’ll have to go to the Central Highlands some time.”

“Somehow, yes. Who did you talk to?”

“Moses and I discussed nickel-steel paving needs, Ramesh and I discussed what support Mars Metals could provide to Marfab, and I talked to Sanjay about the metal needs of Uzboi Industries. Overall, I was able to increase the positions Mars Metals can advertise for by sixteen. How many positions did the meeting generate?”

“Other than the two thousand related to gold production, close to three thousand, so we now have 7,500 positions for 4,000 people. People will be adding their plans and job descriptions to the website for a few weeks. Generally, it is better to have too many positions available than too few, but not this many.”

“Will we have the money to support 4,000 positions?”

“I have to talk to Park and Yuki about that in the next week, but we’ll manage if we give a lot of them to the gold mining companies, since they’ll pay the salaries. June Addison wants to hire twenty-five more people to work on improving gaseous core nuclear engines; she thinks with theoretical work on Earth and experiments on Deimos, they can get the specific impulse up to 4,000 seconds. Reggie Pearson wants twenty-five more staff to work on improvements to the reactors, especially the radiators needed for use in space. He’s sure two 15-megawatt reactors and their radiators can mass less than a

hundred tonnes and can power an ion propulsion system to send a galleon to Uranus.

Martech wants to hire another hundred geologists and exobiologists.”

“And Alexandra was talking about three hundred more people to speed up galleon production, though who knows whether we need it!”

“That’s the problem. This huge immigration really cannot be planned or managed very well and has the potential to create a thousand messes.”

“Were you trying to ensure a sort of final legacy for yourself?”

Will considered the question. “Maybe that was one motivation: go out with a bang. But I’ve always favored maximal immigration. That had much less potential for confusion when we were talking about going from 100 to 200 immigrants, though. Over the next few months, the cabinet members and I have to go through a mass of ideas, from brilliant to crazy, prioritize them, prune the weaker ideas, fund the better positions, and justify the resulting choices to fifty anxious managers who are sure we have misunderstood or undervalued them. I figure we have about six months to do it, too.”

“Well, if anyone can do it, it’s you!”

“I’m not so sure, at 71 years old!”

“Your energy has held up pretty well.”

“I suppose.” Will considered a moment. “I have another concern, though.

Opposition is February 14, 2074. The real craziness will occur in two phases: phase one starts this fall when we start launching people to orbit and ends about December 30, 2073, when the last vehicles depart Earth; phase two starts in the fall of 2073 when the vehicles begin to arrive and we have to deorbit the arrivals, get them to their housing, and get them started in their work. That’ll continue until June, 2074. But the vernal equinox is

October 7, 2073. Usually, elections would be late October, but I can propose to the Council to postpone them as much as six months, which is April 7, 2074. I am wondering whether I should postpone the election and how much.”

“And if you are willing to be reelected, it won’t matter, because you’d probably be reelected.”

“Exactly, so postponement is a signal of my intent. That could make me a lame duck, and I have ethical concerns about signaling my intention to retire because that influences the voters, which I don’t want to do.”

“I don’t think you should worry about signaling intent. If there’s some turmoil, it’s a bad time for an election anyway, and even if you were reelected, there would be some transition.”

“But I wouldn’t argue that trouble getting people off Earth causes turmoil for voters here. The arrival period is always tumultuous, so that’s an argument for holding the election as late as possible.”

“People feel a lot of tension during the launch phase, though. I think it’s legitimate to ask for the election to be postponed to January.”

“I suppose I shouldn’t worry about how people will speculate, either.”

“They might even speculate you want to postpone the election to improve your chance of being reelected, which is the opposite of the speculation you were worrying about.”

“Good point. I should wait and see how things develop over the next few months, anyway.”

“Definitely. And come to bed, you can only do so much in one day. There’s always morrowsol.”

Will nodded. “Okay.”

12.

Solar System Summit

Late October 2072

Conference Room One on the first floor of the Commonwealth Building was slowly filling with the invitees. Will came down the stairs from his office just two minutes before the official start. The five ambassadors to Mars had arrived and Will greeted each one and their assistants with a handshake and friendly conversation. He was particularly warm to Mariella Fsadni and Shiva Ramnath, the European and Indian ambassadors, with whom Jacquie Collins had had extensive conversations in recent sols. Each ambassador had a table. Will shared another, larger central table with Jacquie Collins, Xiaopeng Cai, Brian Stark, Huma Mubarak, and Yevgeny Lescov. Lal Shankaraman, as speaker of the Mars Council, sat with Alexandra Lescov, their space vehicle designer, and with Louise Tremblay, Director of the Spaceports and of Spacelift Inc., their public corporation that owned and operated Mars's space vehicles. Érico Lopes and Kurt Hollinworth, heads of the Saturn and Asteroid Belt Commissions, sat together with Benigno Melos, the Brazilian consular officer, a former astronaut who had emigrated to Mars earlier that year.

“They’re running late in Houston,” said Will, pointing to the left half of the wall screen, where the video showed a milling crowd of people. Two curved lines of desks had little signs indicating the seating arrangement; two dozen space agencies were present. Pete Theodoulos, the Marsian Minister of External Affairs, was there talking to a group of people.

“In Beijing they’re disciplined, though,” noted Xiaopeng, with a smile. The Chinese delegation sat in the middle of a long curved table, with the Japanese, Korean, Australian, Indian, Malaysian, Indonesian, Russian, Pakistani, and Iranian space officials arrayed to their right and left. The head of the Jupiter Commission, which was headquartered in Beijing, was present. Ruhullah Islami, Mars’s roving ambassador, was seated as well.

“Could we please begin?” asked Dr. Cheng Weiming, the head of China’s space agency, and therefore chair for the Asian part of the space summit. It was 8 a.m. in Beijing and 7 p.m. in Houston. They had five hours for a meeting, then another session thirty-seven hours later when it was 9 p.m. in Beijing and 8 a.m. in Houston. In between there would be small group discussions and informal negotiations. Aurorae’s clocks at the time were almost an hour earlier than Beijing’s, so it was an early gathering for them.

The people in Houston immediately responded and began to sit. The Marsians waited; that day round trip communications took about thirty-five minutes. The Houston and Beijing gatherings exchanged greetings while they waited for the Marsian video to arrive.

“We want to thank our Marsian colleagues for calling this gathering,” began Cheng, inaugurating the formal program. He spoke in Chinese with simultaneous English translation. “It was a wise decision, and we in China are grateful to learn what they have in mind. For a year or more, Marsian space policy has been raising questions in many capitals. We have an opening presentation by the Marsian Minister and Assistant Minister of Space Exploration, Dr. Jacqueline Collins and Dr. Xiaopeng Cai. It alternates in

English and Chinese with subtitles for the other, and there is also an audio translation on your headphones. We will start the presentation in ten seconds.”

Cheng sat and the camera turned to the screen on the wall in Beijing. After several seconds, Jacquie Collins’s face appeared.

“Greetings to all of you at the first Solar System Exploration Summit. I am Dr. Jacqueline Collins, Minister of Space Exploration, which is a Cabinet-level position here in the Marsian Commonwealth, and this is my colleague, the renowned eobiologist Dr. Xiaopeng Cai, Assistant Minister for Space Exploration. Our presentation about Marsian space policy will be brief and we hope it will help clarify many matters. The fact that space exploration is a cabinet-level position, rather than a government agency, itself underscores the importance of space exploration to us. But why is it so important? Let us consider a few statistics.”

They switched to a slide. “You can see the number of employees we have on Mars in a series of twenty space related fields in science and engineering, such as astrogeology, geophysics, exobiology, rocket engine engineering, space vehicle construction, astronavigation, remote-controlled robotic construction, robotic surface exploration, and life support systems engineering. These numbers are compared against two contrasting terrestrial operations; the Jet Propulsion Laboratory in Pasadena, California, and the Prometheus Shuttle Corporation in Moscow. You will note that our numbers are comparable to either one or the other, and in many cases our numbers exceed them. The total population on Mars with Masters degrees or doctorates in space-related fields exceeds the number employed at JPL and is equal to about twenty percent the total in the

United States or China. Some of the latter work under grants given by the Marsian Commonwealth as well.”

Another slide appeared on the screen and Xiaopeng continued. “Here we have a slide of the population of Mars, from the present to its projected level in 2082 ten years from now. This assumes a continued expansion of immigration averaging forty percent per columbiad and childbirths at the replacement level. As you can see, the present population of 11,000—which is equal to two thirds the number of employees of NASA—increases five fold to 55,000. This expansion is possible because the cost of immigration should drop from one million redbacks per immigrant this year to a quarter million each by 2082. Thus the increased Marsian population will be spending roughly the same amount on immigration a decade from now that it spends today.

“And here’s a slide showing projected GDP expenditures. Construction will continue to consume twenty percent of our economic output; that’s essential to accommodate arrivals. Education and health will consume ten percent more and most of it is devoted to education because our median age is 30, and it will remain about 30 as long as we encourage the immigration of people in their twenties. Health and retirement remain small fractions because of our comparatively young population; this is the huge difference between Marsian and most terrestrial societies. Space exploration and related technological development gets ten percent of our budget. Immigration takes twenty-five percent and it is projected to decline. That leaves thirty-five percent for domestic consumption; lower than in terrestrial societies, but plenty to provide for our population. Domestic consumption should increase to forty percent of our GDP in five years and could hit fifty percent by 2082.”

“If Mars ever ceases to devote forty-five percent of its GDP to transporting and housing immigrants, within a few decades it will have to devote a similar percentage—at least thirty percent of its GDP—to health and retirement,” continued Jacquie. “This influx of skilled, educated people makes Mars the most dynamic, creative, and forward thinking society in history. They want to do big things. And as long as they don’t have to maintain a military, the defense budget can be devoted to space exploration. That explains why we want to explore space: we have the human resources, we have the financial resources, and we have the vision and desire to do so. We have no one on Mars arguing that we should be spending more money on poor people, on robots, or for that matter on other things that get similar priority to space exploration on Earth, such as purchase of pet foods, which actually consume more GDP in most countries than space exploration.”

Another slide appeared. “Currently, sale of 1,000 tonnes of gold, PGMs and deuterium every annum—roughly every two Earth years—brings Mars an import income of about 36 billion redbacks,” continued Xiaopeng. “The Marsian population produces other goods and services equal to 4 billion redbacks. Forty billion redbacks per annum—eighteen billion per Earth year—is somewhat larger than NASA’s budget. While we devote only ten percent of that to space exploration directly, the twenty-five percent devoted to bringing arrivals to Mars is also space related and helps guarantee our focus and maintain our high efficiency. As a result, we are roughly as productive as the United States, where space exploration is concerned, which in turn devotes about as much to space exploration as the rest of Earth. In other words, *the Marsian space budget is in effect one third of humanity’s expenditure on space.*

He paused to let the point sink in. “There is absolutely no reason for us to devote less to space, either. Our commitment is permanent and can only grow over the next decade as our educated, skilled population grows. It is a simple projection of numbers to see that ten years from now, the Marsian space effort will be larger than all of Earth’s. It might be double Earth’s, in fact.”

“But as we have repeatedly said, our purpose is not to dominate or control space exploration,” said Jacquie. “We want to partner with everyone. The last six years have shown that a planet or planet-moon system is best explored by a permanent community with rotating members. That community needs a critical mass for production of necessary goods, scientific research, and meeting educational and medical needs. It appears that the community needs to be at least several hundred adults; 300 to 500, more if they are farther away and require more time for travel, less if they are closer to Earth and Mars. That community needs to have a single organizational structure, should be multinational and multicultural, and should have a substantial say in its future development. Our role is to plant the communities, support them, and improve the technology that will make it possible for them, one day, to contribute economically as well as scientifically to humanity’s destiny. Such communities are possible on Mercury, in Venus orbit, on the moon, on Mars, on Ceres and possibly other asteroids, on Callisto, on Titan, on a moon of Uranus, and on a moon of Neptune; nine principal places. For this reason, Mars wishes to make a commitment, over the next eight years, to producing one galleon for Venus, one for Ceres, two for Jupiter—one to stay and one to go back and forth—one more for Titan, two for Uranus, and two for Neptune. At one billion redbacks per vehicle, that’s nine billion redbacks. This is an easy commitment for us to make because we produce

galleons; in eight years we hope to produce sixteen of them, the other eight being for the Earth-Mars transportation system. In 2083-86 we'll produce two more for Uranus and two more for Neptune.

“In addition to that commitment, Mars also has several other specific commitments it wishes to make,” said Xiaopeng. “We plan to improve our eighteen-tonne, fifteen-megawatt reactors to increase their power output thirty percent and complete development of a thirty-tonne radiator system so that they can operate in space. We aim to increase the specific impulse of our gaseous-core nuclear engines from 2,500 seconds to at least 3,500. We hope that someone will develop a 30-megawatt VASIMR or advanced ion engine with a specific impulse of at least 5,000 seconds; powered by two of our reactors. Such a propulsion system could take a crew to Uranus in two years and to Neptune in three. We also plan to devote some research to improved life support systems, better domes, and better surface transportation systems, all of which benefit Marsians directly.

“These are commitments that are natural and easy for us to make,” concluded Jacquie. “They come from Mars’s natural strengths. We wish to supply multinational personnel to all these places and want to collaborate with others as well. The list of commitments that others can make is quite long. All these worlds need probes, androids, satellites, and other remote exploration systems. The systems need to be developed by terrestrial engineers and scientists. The worlds need research by terrestrial scientists, especially Uranus and Neptune, in preparation for the arrival of communities to those places. All of your countries can contribute personnel to the Uranus and Neptune missions; the cost would be about 2 million redbacks per astronaut per year, which covers

vehicle and support costs. We look forward to further discussion with all of you about plans we can implement together to explore the solar system.”

Jacquie Collins’ face faded. Cheng Weiping looked around at the audience in Beijing. “We are all very appreciative of the decadal commitment that the Commonwealth of Mars has made to the exploration of the solar system. The presentation was impressively detailed and clear. Mars’s development of the Phobos drydock has been innovative and has in itself led to a great advance in spacecraft design and construction. China is committed to purchase of galleons and caravels from Phobos and continuing its development. We are also committed to gaseous core engine development at our Deimos reservation. Our commitment to the Chinese presence on Callisto is also permanent and ongoing. China is happy to collaborate with other nations, but it will not compromise its sovereignty over any facility on the surface of another world. It also remains very concerned about any potential expansion of sovereignty of any other nation over existing outposts or the planting of national outposts that claim entire planet-moon systems. These are long-term Chinese policies as well. I believe Peter Zubko, my colleague at NASA, also has a comment to make. Dr. Zubko.”

Will looked at the others, then to Mariella Fasdni and Shiva Ramnath. It appeared that the Chinese and Americans had coordinated their positions, just as the Indians, Europeans, and Brazilians had. They all turned to the right-hand screen to watch Zubko rise.

“We share many of the concerns of our Chinese colleagues,” he began. “We favor peaceful cooperation and competition in space as an expression of our national interests and identities. Jupiter has proved a good example of such competition and cooperation.

We are interested in the development of many of the propulsion technologies our Marsian colleagues have mentioned. In the next decade we will develop and build a space vehicle construction facility in low Earth orbit to produce a successor vehicle to the galleon. We invite Marsian participation in that project. We plan to develop advanced ion engine propulsion system with a specific impulse of 10,000 seconds and again welcome multinational participation. Using such an engine, we propose a multinational mission from Earth to Neptune in the 2085-90 range. We will continue to support the Mercury and Venus efforts spearheaded by our European colleagues and will continue to send missions to Earth-crossing asteroids. We will maintain and expand our investment in Callisto. Back to you, Dr. Cheng.”

“Thank you, Dr. Zubko. Dr. Helene Dupont of the European Space Agency.”

While Dupont, who was in Houston, rose to speak, Will looked at Jacquie and Xiaoping, both surprised and angered. “The US proposes to do almost everything we have proposed?” he whispered.

“It must be a ploy to make us look uncooperative,” said Jacquie.

“And without us, Congress would never authorize the money,” said Will.

Meanwhile, Dupont began. “ESA is delighted to see so many formal commitments to exploration of the solar system. Mercury and Venus will be our priority over the next decade, with the former expanding to 200 people at Concord Station and the latter expanding to 200 at Magellan Station, thanks to Mars’s commitment to provide a galleon to the latter. Our big project will be Project Aeneas, named for a son of the goddess Venus, to supply Magellan with one or more small asteroids over the next decade, thereby providing the station a permanent location in orbit with cosmic radiation

shielding and a source of propellant. We will also continue our participation in the Saturn and Asteroid Commissions and will join the Uranus and Neptune projects Mars has outlined. While the scale of our commitment remains to be determined, it will go beyond token amounts.”

That caused some murmurs. Will looked at his colleagues and nodded affirmatively; they expected that. Dr. Cheng next recognized Rama Singh, who was located in Beijing. He rose.

“India is in a unique position in this gathering in that the recent war did no direct damage to our economy. Unlike Europe, Japan, and China, we do not have a huge percentage of our population that is aging. As a result of the damage done to China’s economy, India has caught up with her and is projected to surpass her in the next decade, becoming the Earth’s second largest economy, as is fitting for the country that now has the world’s largest population. Ten percent of the population of Mars hails from India, a percentage that will increase next year. Our participation in the Saturn Commission has been highly successful and we are very pleased with the leadership Mars has provided in space. Therefore, India intends to be a major partner with Mars in the Asteroid and Saturn Commissions, will route its participation in Callisto through Mars, and will be a major contributor to the Uranus and Neptune Projects. Our participation will focus on provision of personnel, but our scientists and engineers will also contribute to the technological advances necessary to strengthen solar system exploration. In particular, we will place a system of communications, GPS, and data collection satellites in the Uranus system in 2078. We have also committed to participation in Project Aeneas and to

continued participation in Magellan and Concord. We intend to be a major player in the plan to settle the solar system.”

“Tanya Pokorny,” said Dr. Cheng, recognizing the representative of the Russian space agency.

“We second the support of our Indian colleagues. Russia is proud to be the seat of project Prometheus and over the next decade we will continue to refine and improve this new shuttle to low Earth orbit. Our collaboration with Mars has been highly successful and mutually advantageous. Consequently, we intend to support the Saturn, Asteroid Belt, Uranus, and Neptune efforts fully. We are particularly interested in the development of advanced ion propulsion.”

Will smiled at that; they had expected Russian, Indian, and European support. The Brazilian representative, speaking next, also supported Mars. But the Pakistani representative, speaking next, was an unknown. “Pakistan also fully supports Mars,” he said. “We are grateful for the leadership and inclusion they have consistently shown. We have no separate project of manned spaceflight and will continue to route that aspect of our space participation through Mars and the Commissions it supports. We can commit to funding fifteen personnel per year.”

“I think we’re getting a little momentum,” whispered Will.

“As expected,” agreed Jacquie. “The specter of holding the summit in Paris and New Delhi forced the Chinese and Americans to host. They knew they couldn’t force others to remain neutral.”

Many representatives wished to speak and Cheng went down the list, alternating between Beijing and Houston. In the next forty-five minutes, fifteen countries committed

to supporting Marsian projects. Zubko looked upset; Cheng pensive. “We’ve now reached our previously agreed on time limit,” he said. “And turn the program over to our colleagues on Mars to respond. We will take a half hour break while awaiting the arrival of their comments.”

Jacquie Collins rose and went to the front of the room. “Thank you, Dr. Cheng,” she replied. She fiddled with the controls on her tablet and froze the scenes in both Houston and Beijing; it would be distracting for them to be talking while the terrestrial audiences were milling around. “Érico Lopes of the Saturn Commission is our first speaker.”

Érico rose. “The Saturn Commission can only make commitments after its Board meets, and that hasn’t happened yet. Hence I cannot speak on its behalf, other than to say we are excited by any support that any member state offers, and we are particularly thrilled to receive the commitment of a second galleon to the passenger run to and from Titan. The *Cassini* has revolutionized the situation on Titan. People who had committed to leave have agreed to extend their stay. The crew at Acheron is reexamining the outpost’s plan in order to accommodate more people in the gravitied space provided by three rotating galleons. They have also initiated projects designed to make Acheron a more pleasant and varied environment. In short, Acheron Outpost is a permanent settlement now, even though part of the crew present will change every two years. They have a committee to plan future expeditions across the face of Titan, to the various moons, and to support remote study of Saturn itself, much of which is done at various universities on Earth. I know I speak on their behalf when I say they are thrilled by the framework that the Marsian exploration plan gives them. If anything, they want to see

more details; projects to explore Titan's subsurface ocean and establish robotic bases on the major moons, for example. I will work closely with the Marsian Commonwealth to further the Saturn work."

Érico sat and Jacquie called on Kurt Hollingworth. His support was much less predictable. He rose. "The Asteroid Belt Commission is very excited to have the commitment of a galleon to bolster the Ceres outpost. Ceres has been doing excellent work in the last five years. Progress on the deep drilling project, though slow, has continued, and PGM extraction was recently restarted. The Ceres residents have recommitted themselves to maximal self-support, continued exploration of their dwarf planet, and outward reach to the Belt around them. A galleon on the surface will allow the *Piazzi* and the *Olbers* to fly missions of up to 15 months duration to nearby asteroids. The Commission has been drafting a plan that involves personnel rotation every two years, alternating between Earth and Mars as the launch point, the flights always making stops either on the way out or on the way back at at least two asteroids. This plan will require the commitment of two pairs of caravels, preferably three. While the Commission is opposed to the resolution of Ceres residents to become an extraterritorial borough of Mars, it has also been assured that the plan will not effect the relationship between Central Outpost and the ABC in any way."

Hollingworth sat. Jacquie looked at Will, who nodded. "Chief Minister Elliott also has a few comments to make."

Will rose. "The Marsian Commonwealth has been developing its solar system exploration policy for nearly two years and it has already been modified to accommodate the ideas and contributions of other nations. Our initial proposal for a galleon for

Mercury, for example, was turned down by the Mercury Commission on the grounds that it was unnecessary, but we have committed to passenger flights between Mars and Earth via Mercury every columbiad and similar flights via Venus whenever the planetary alignment permits. The plan of the Asteroid Belt Commission to use pairs of caravels for Ceres resupply and exploration is new and we will examine it carefully to see what commitment we can make to it. Mars owns a large number of caravels and they will gradually be phased out of the Mars-Earth run as more galleons become available.

“Mars’s commitment to collaboration remains solid. We have no desire to compete, in the rough and tumble sense of that word, though we will vie with others in the accomplishment of mutually accepted goals for expansion of the human presence. If we are not welcome, as may be the case, for example, in the jovian system, we will leave the development of that place to others. We have no desire to muscle in, to steal glory from others, or to provoke retaliation. We seek a solar system expansion plan that is based on science and on the desires of the settlements themselves. The issue of the relationship of the residents to the Marsian government is also not relevant to our support, which will not come with political strings attached.

“We want to see the existing settlements consolidated and expanded at a reasonable pace and the human presence move outward by one planet per decade until all the major planets have a settlement. That is the essence of our exploration and settlement plan. Together, the goals are very achievable, and we look forward to working with everyone to achieve them on a mutually agreeable timeframe.”

“Thank you, Mr. Chief Minister,” said Jacquie. “I believe that is all we have at this end, so now we will take a thirty-minute break and wait for responses in Beijing and

Houston.” She pushed an icon that stopped the transmission of sound to Earth and everyone rose to stretch their legs.

“That was a really good presentation,” Will said to Jacquie and Xiaopeng. “Clear, to the point, well illustrated, and the alternation of voices and languages drove home the point about our consultative, multinational approach.”

“That was what we hoped,” said Jacquie. “It seems to have been well received, also. It was posted to the *Mars This Sol* website simultaneously to the presentation, so now everyone can see it if they wish.”

“And the various informal commitments we received over the last few weeks came through,” said Xiaopeng, smiling. “The momentum will be hard to stop.”

“The bigger problem will be seeing the commitments materialize,” said Will.

Just then Ambassador Zhao Tao approached them. “Mr. Chief Minister, I am puzzled by something you just said. You noted that ‘relationship of the residents to the Marsian government’ such as on Ceres ‘is also not relevant to our support, which will not come with political strings attached.’ Now, sir, how is that possible? How is that an honest statement?”

“Mr. Ambassador, are you suggesting we would bribe Ceres to become a borough of Mars?”

“Surely if Ceres becomes a borough, they can expect to benefit financially?”

“That’s a different matter. If they were a borough, they would have a special relationship that would obligate us to support and develop them. But Mars isn’t made of money; it doesn’t have bottomless pockets. The Mars Council has to consider that matter very carefully and should hesitate to bestow such a status on Ceres. Right now we’re

skimming off the most concentrated of Mars's mineral riches. But Cassini and Dawes are already experiencing declines in gold production, in spite of the import and construction of enormous machines and the provision of nuclear power. Our production costs will continue to rise. PGM production is guaranteed to stay profitable, but Ceres and other places are competing increasingly. Most nations that depend on mineral production experience large income swings. That anonymous editorial is causing Mars a lot of possible trouble!"

Tao smiled. "So you regret writing it?"

"I regret that someone wrote it!"

"Do you deny that it is in Mars's best interests to make all of the solar system into boroughs?"

"I certainly don't think China will become a borough, Mr. Ambassador!"

That caused laughs, but Tao's face turned red. "You know that isn't what I meant."

"I do know what you meant. I doubt it is in Mars's best interest to have boroughs on Titan, Titania, Triton, Ceres, Mercury, and for that matter, Callisto. There are the economic implications; we are too small to support all of them in an emergency, and none of them will be self-sufficient economically for many decades. But more serious is the issue of identity. I don't think the people in those settlements are ready to make 'Marsian' their primary identity, and Marsians certainly are not ready to abandon the word 'Marsian' for some other adjective. So, what would we be? This is not a trivial matter and I don't think inventing an adjective like 'solarian' is the solution."

“I see your point,” agreed Tao. “But the Pacific Ocean is dotted with islands, and many of them are ‘American’ even if ‘America’ is thousands of kilometers away.”

Yes, but the adjective ‘American’ was not tied to a particular piece of land. The noun ‘Mars’ is.”

“Even so, the majority of the people on Titan and Ceres and nearly a majority on Callisto are Marsian citizens, and they are probably going to stay in those settlements only part of their lives. The rest of their lives will be spent on Mars, and they don’t want to break their ties with that world.”

“And for a lot of them, a nation on Earth is home as well. The vast majority of Marsian citizens are also citizens of a country on Earth. Tang Enlai is a good example.”

“True, but ‘Mars’ has acquired a special cultural significance; young people on Earth yearn to come here. I think ‘Marsian’ is a more attractive adjective than you suggest.”

“You may be right,” conceded Will. “But we don’t know how this will evolve, Mr. Ambassador, and that is my point. I don’t think Mars should rush into a sort of solar system imperialism. It is wiser and safer to collaborate, it is financially prudent to do so, and it is part of the Marsian way to do so, anyway. If we don’t work together, we don’t survive.”

“I will concede that, Mr. Chief Minister,” agreed Tao.

There was a pause in the conversation. “I do hope Mars can collaborate with the United States in some of the projects Dr. Zubko outlined,” said Danforth.

“We will certainly look at them closely and see how we can collaborate,” said Will. “Our space reactors may be useful to an orbital vehicle assembly facility, for example.”

“We are hoping for a very favorable response,” added Jane Kohl.

“Perhaps you will receive one,” replied Will, very tentatively.

Danforth opened his mouth to reply, but Ambassador Shiva Ramnath interrupted him. “In my opinion, Mars would be foolish to allocate its resources for some of your projects, and we know Mars is not foolish. It looks like a diplomatic ploy to embarrass Mars, to me. Orbital vehicle assembly facility? NASA wants to spend ten times as much money as Mars has to duplicate its facility on Phobos, but without the radiation shielding? If Phobos needs to add another hydrogen tank, they just anchor it to the bedrock and attach it to the pipeline. In Earth orbit you either make it free flying and watch its orbit constantly, or you attach it to your facility via a large and expensive structure that has to be hauled to orbit in pieces and assembled. Your solar panels are in darkness half the time and no one will let you set up a big reactor in low Earth orbit, in case an accident deorbits it. Everything needs shielding against orbiting debris, while on Phobos they just cover everything with sandbags! Besides, Congress will never fund it anyway! As for a successor to the galleon, Mars has already been designing such a vehicle and everyone knows it. And Mars has already proposed flight to Neptune, too!”

“And note who wants to work with Mars,” pointed out Mariella. “Either the smaller countries that have to collaborate with others, or the European Union, which has been developing its collaboration for over a century, or India, which has a history of

collaboration! The United States and China always want to be in charge, and if they can't be, they'll take their marbles and play somewhere else!"

"That's Callisto," agreed Benigno, the Brazilian representative.

"Never mind," said Will. "The purpose of this summit is to bring us together about exploration, not dwell on the past."

The meeting resumed a half hour later with a second round of comments from Earth. During the half hour, some space agencies had had time to discuss their plans further, for the summit was being webcast to dozens of offices. Both the Chinese and the Americans announced plans to expand their Callisto operations, and the Chinese made concrete their plan to improve gaseous core engines, while the Americans committed more definitely to a 30-megawatt advanced ion propulsion system. The Indians committed to providing fifty positions on every galleon Mars launched to the outer solar system, which caused a few surprised gasps. Later, the Europeans matched the number, and various other nations made commitments equal to another fifty, thereby half filling every galleon going to Jupiter, Saturn, Uranus, and eventually Neptune. Brazil committed to supporting one caravel exploring the Asteroid Belt every other year with the stipulation that some of the positions could be swapped with others' commitments. When the meeting broke up at noon, Beijing time—10:25 a.m. in Aurorae and 11 p.m. the day before in Houston—a substantial number of commitments had been made toward an overall plan.

Then the media wars began, as everyone issued press releases and competed for prominence in the news summaries. Will Elliott and Jacquie Collins were busy half the afternoon with a rolling news conference; the questions came in as videomails and the

answers went back out the same way over a public channel. They also did several exclusive interviews the same way. Since the summit had been Mars's initiative, they were able to shape the perceptions of the first session fairly well.

That done, the cabinet met to discuss the next steps; what additional offers to make and how to respond to the offers made, especially those by the U.S. and China. They received lengthy reports from Pete Theodoulos and Ruhullah Islami about their conversations in Houston and Beijing. Informal discussions with various national representatives began. But neither the Americans nor the Chinese approached Mars with a plan to cooperate with the Red Planet.

It was suppertime the next evening, just two hours before the last public session at 8:30 p.m. Aurorae time, 9 p.m. Beijing time, and 8 a.m. Houston time, when Ambassador Danforth and Dr. Jane Kohl came to the Commonwealth building to meet with Will, Jacquie, Xiaopeng, and Brian.

"The President and Vice President themselves have both been involved in discussions at a large space policy gathering held at the White House over the last twenty-four hours," he began. "The summit proved to be a good time to review American goals in the light of the priorities of other countries. We see that the United States, Russia, and Mars are all interested in advanced ion propulsion with very high specific impulses; 10,000 seconds or more. We see a synergy of contributions from all three and want to propose a joint project under our leadership. Mars doesn't have ion research to speak of, and the Russian effort is smaller than ours."

"That's fine with us," said Will. "Assuming the project has clearly defined goals and a reasonable timeline and budget."

“We’ll commit a galleon to the Callisto surface facility if Mars commits its galleon to providing round trip passenger transportation. It can hold 150, maybe more if we build subsurface facilities like Titan’s, and we’ll commit seventy-five berths and leave the other seventy-five to Mars and other nations to fill.”

“We’re also willing to do some swops,” added Jane. “We’ll fund an American to go to Titan or Ceres in return for an additional Marsian to go to Callisto.”

“What about the caravel there now?” asked Brian.

“We’ll either leave it there or replace it,” replied the ambassador. “We’ll keep one caravel on Callisto for jovian system exploration.”

“And commandership?” asked Will.

“We want an American in charge half the time. The command can alternate between an American and someone Mars chooses.”

“I’m referring to the commander on the voyage out,” said Will. “Because once the crew reaches Callisto, they will be electing their commander.”

“Oh?” Danforth said, startled. “We don’t want the commander of the joint mission to Callisto elected.”

“No? You want the United States to oppose democracy in space?”

“I see.” Danforth looked at Kohl.

“That would be a problem,” she said.

“It sure would,” agreed Will. “Especially after the media summarizes all the problems Callisto has had up to this point.”

“We’ll have to agree to that,” conceded Danforth.

What do you think of the idea of Mars choosing a Chinese-Marsian to command?
I think you can see all sorts of implications.”

Danforth chuckled. “I wonder what our Chinese colleagues will do with that! I’ll ask about that, but I think it’s alright.”

“You aren’t requesting any exclusive arrangements?” asked Jacquie.

“No. As was observed yesterday, Congress is not in the position to spend; we have a huge amount of rebuilding to do, printing money has caused rampant inflation, and the government’s credit, as a result of the war, is terrible. Projects are more likely to get funding if they have transnational partners. But we can continue the funding for Peary, Callisto, and advanced ion technology. We can also devote billion redbacks—a hundred billion dollars, until Congress passes a bill to slash two zeros from our currency—to satellites, rovers, and androids for the Uranian and Neptunian systems. We want to collaborate with you on Project Uranus and invite you to collaborate with us on Project Neptune, to establish a settlement on Triton in the late 2080s. We anticipate that the latter will need galleons or a larger successor vehicle and advanced propulsion, but that the surface technology is mostly developed as a result of Callisto and Titan. The cost, therefore, won’t be very high.”

“That’s our understanding,” agreed Will. “Your invitation is very welcome and accepted, provided that the details prove friendly and reasonable, and the votes are apportions based on contributions.”

“The details will still have to be worked out. Assuming each country sends a galleon, for example, we’ll have to decide how the command will be handled. We still need to determine how many people we’ll send, how much technology each participant

nation develops, how much cost is reasonable and what constitutes an overrun, how many votes every nation gets, etc.”

“But it sounds like we have the basis for a Uranus Commission and a Neptune Commission. You would have no objection to China joining, for example?”

“No, anyone can join.”

“Good.” Will smiled. “The Uranus and Neptune communities will be electing their leadership, too.”

“I suppose.”

“What about the plan for a successor to the galleon?”

“We doubt Congress will approve it. We’ll hold off on that one for now.”

“Alright,” said Will. “I think you have a good plan for collaboration. Let’s fill in the details starting morrowsol.”

Arthur Danforth smiled. “Thank you, Mr. Chief Minister. I need to run your questions past Washington, but I think we can get that done before the closing meeting tonight.”

“Let us know if there are additional questions. We’ll tackle them right away,” replied Will. He rose and shook hands with Danforth, then the latter and Jane Kohl walked out of the room.

“We did it!” exclaimed Jacquie, excited. “I’m not sure we could have gotten much more.”

“The devil will be in the details,” replied Will. “I wonder whether we can get enough Americans going to Titan and Ceres to reduce their share of the berths going to Callisto to fifty or even forty. That would be quite an achievement.”

“Especially if China made a similar agreement,” said Xiaopeng.

“Call Ambassador Tao,” said Will to Xiaopeng. “Give him an informal, oral report about this meeting and see what the Chinese will offer us. We could easily fly three galleons to Uranus or Neptune at once; we do not need to stick to just two, one Marsian and one American.”

“We can also offer to collaborate with gaseous core engine development, since we are expanding our team,” said Jacquie. “Working with their team, we can probably make some important progress on the technology.”

Will nodded. “That, too. The Chinese don’t want to be left behind; they have a very tight budget, too.”

“Okay, I’ll do that right away,” agreed Xiaopeng.

13.

Ceres Resolution

Nov. 2072

“Aren’t they cute?” asked Jefferson Woolsey, as he and Will Elliott approached the marsoform containment.

“You sound like the father of a newborn!” replied Will.

“Well, they are my babies; the only ones, so far.”

Will looked into the containment. The floor was covered by regolith; the ceiling had powerful grow lights that produced the full spectrum of sunlight that fell on the Martian surface, including ultraviolet; two of the walls were heavy glass, while the other two were metal. The regolith was covered by a dozen of small dark green blobs.

“Is the containment providing fully Martian normal conditions?”

“Not yet. The biggest difficulty is the transition from terrestrial conditions to Martian. Terrestrial cacti can’t reproduce in Martian conditions, so we can’t do genetic engineering on them to make them survivable in Martian conditions, and cactars can’t grow in terrestrial conditions either. But I think we found a transition environment—about a tenth of an atmosphere—where we could engineer a cactus to become a cactar. These guys are down to 0.03 terrestrial atmospheres—about four Martian atmospheres—and they’re doing fine. They’re growing. The big problem is getting them down to Martian ambient, because their interior cavities will get above the boiling point of water during the day. We think the combination of hydrogen peroxide and organic chemicals in the liquid will keep it from boiling, though.”

“Amazing. They’re so dark, they must absorb most of the sunlight falling on them.”

“Seventy percent; it warms them up to as much as thirty Celsius, and the interior temperature tends to stay above freezing part of the night. Most of the plant’s growing occurs there; the tough ‘spacesuit’ exterior grows slowly and is fed by the nutrients and sugars produced underneath. The skin, by the way, converts the ultraviolet from the sun into red light, which the chlorophyll can use. The plants actually glow in the dark for a half hour after sunset!”

Will chuckled. “Really? And the interior accumulates the oxygen?”

“Oxygen and hydrogen peroxide. Right now we dust these plants with snow once a month; it melts on their outside and is absorbed, or is absorbed through their holdfast.”

“How long before they’re down to Mars ambient?”

“Three or four months, then we’ll see how well they grow and whether they start to bud. They send out a root horizontally underground about half a meter, then produce a new barrel. We think under Martian equator ambient conditions they should be able to bud every two or three annums.”

“So, that’s a meter every decade, let’s say, and Mars is twenty-two million meters around. It’d take a long time for them to cover the surface!”

“If the entire surface were covered by cactars, they’d convert about a tenth the atmosphere into oxygen! Of course, that’d just cause less CO₂ frost accumulation at the poles; the air pressure probably wouldn’t drop. We’d be pretty busy dusting them all with snow, too. We think an adult cactar can go about a year between dustings. They should be able to grow to half a meter around; big, dark green spheres covering the surface.”

“What about dust?”

“The wind should dust them off periodically. Very fine dust particles are their main source of nutrients, especially when we dust them with snow. The holdfast doesn’t interact with the regolith much. We had hoped they could; maybe the next generation will be better. ”

“And we’re doing a new generation every columbiad?”

“Three quarters of the research is being done on Earth, and once every columbiad their results can be shipped here in the form of frozen tissue or live plants. It takes us six months to a year to convert their results into something that works here; we have to assemble the actual living plant from various genetic combinations.”

Will nodded and stared at the little spheres, which were barely a centimeter across. They looked like dark green cherries. “When can the first batch go outside?”

“So, you think we can handle the controversy?”

“I’m ready, Dr. Frankenstein, if you are.”

“Really? These things can’t flower or make seeds; they can only reproduce asexually through budding. So it’s pretty easy to rip them up and remove them, if we want to. The microorganisms living in the cavity that fix nitrogen from the air and produce some of the hydrogen peroxide can’t reproduce outside; they’re killed by the ultraviolet. Martian microorganisms can’t live inside the cavities because of the oxygen, either.”

“These are pretty good arguments and we have already been making them to the Marsian public. I think people will accept them, too, though cactars are guaranteed to be controversial. When can they go outside?”

“About a year; we’d like to get them up to three or four centimeters first.”

“A year? Good. Let’s plan on it. When will the next species be ready, if you can call them a ‘species’?”

“We do; they can’t reproduce together, but they share a common genetic blueprint. Cactar 2 should be ready in three years. It’ll be able to grow to a meter in size, the photosynthesis will be more efficient, and the biochemistry should work better.”

“Amazing,” said Will, still looking at the cactars. “We have, essentially, created life.”

“We have. In a hundred years we’ll probably have created several dozen species; tall, short, different shades of green, and able to handle different conditions. We can probably create species that can handle polar conditions. We might even be able to create a lifeform that can grow on Ceres in a vacuum! We think it’s possible.”

“And the varieties we’re creating inside our domes are pretty amazing, too. It’s a whole new world.”

“Research that is banned on Earth because of the damage the new species could do to the biosphere.” Jefferson turned away from the containment and walked Will back to the offices. “I’m still amazed you got the Chinese and Americans to agree to a plan for solar system exploration.”

“We’ll see whether the agreements hold up, but if they don’t, at least we’ll be free to do our plan. That’s the main reason the agreements are likely to survive. No one on Earth has the money to go it alone, right now. Legislatures are slashing space expenditures. They’ll rebuild orbital infrastructure because it can make money. They’ll rebuild the moon because tourists will return there soon enough and because it has a lot

of infrastructure already. They'll maintain existing commitments, especially if they're in competition with another country. But if they want to do anything new, it has to be in a partnership. And we have enough money to keep the partnerships going. Now, let me ask you a question: should the Council approve legislation to accept the Ceres Declaration?"

"Why are you asking me?" Jefferson laughed nervously.

"I'm asking everyone. I'm trying to gage public opinion. I still have no position, by the way."

"Well . . . it has advantages and disadvantages, doesn't it? They're Marsian citizens, they won't stay there their entire lives and will come back here, it'd be good for Mars to expand its 'territory' to the Belt, but it'll cost us money when they can't cover their expenses, on the other hand if they ever make a profit it comes back to Mars. . ."

"Okay, you've just summarized all the arguments!"

"I guess I have, but I really haven't thought about it enough to weigh the different positions."

"Fair enough. I think that's probably where most people are, right now. People are informed, but haven't weighed in on one side or another."

"Here in Martech's cafeteria, you can hear quite a debate at meal times. But I don't think most people have taken a side; or at least, not strongly. People are leaning for or against."

"I think that's true. It'll be interesting to see what happens when the Council starts to meet next week."

“It’s all gone,” said Will, amazed. The rover had paused at the crest of a hill looking eastward over the ancient vallis torn through the megaregolith of the Central Highlands near Cassini Outpost. He pointed at a huge hole in the ground two kilometers long, 100 meters wide, and 50 meters deep. “When I first saw the Pretoria conglomerate in July 2045 it was a gravel and boulder bar fifty meters high. And now it’s a hole in the ground! And that hill of tailings a hundred meters high didn’t exist!”

“We excavated ten million cubic meters of rock,” said Bruce Curry. “Twenty-five million tonnes, assaying 27 grams of gold per tonne; 674 tonnes of gold altogether.” He pointed at a shiny pile. “That’s a million tonnes of processed nickel-iron meteorite pulled from the Pretoria and Joberg, from which we produced 30 tonnes of platinum group metals and a tonne of gold as well. Joberg is a hole almost twice as large in volume and 100 meters deep, and placer deposits downstream almost the size of Pretoria have also been processed. Altogether, Cassini has produced 2,000 tonnes of gold in 27 years, involving the excavation of 75 million tonnes or 30 million cubic meters of material.”

“It’s an amazing thing,” agreed Will. “How much does Joberg have left?”

“It depends on how deep we dig,” replied Gerhard Bach. “We can certainly excavate to 200 meters and extract another 1,000 tonnes of gold, but the price will be much higher. Lifting everything from the hole is expensive. We can switch to shaft mining and go deeper, but that’ll require several billion redbacks of investment, and active modification of terrestrial robotic mining equipment to work in Martian conditions.”

“I thought Cassini had up to 30,000 tonnes of gold?” asked Will. “You’re talking about a tenth of that.”

“The potential is for three billion troy ounces or 90,000 tonnes,” agreed Gerhard. “But half of that is deep and we can’t go after it without shaft mining. The remaining 45,000 tonnes is scattered in surface deposits assaying 3 to 10 grams of gold per tonne, one quarter as rich as the deposits we have been exploiting so far. The situation at Dawes is similar. Cassini has maybe a decade of rich deposits left; Dawes fifteen years; Meridiani, Thymiamata, and Kalgoorlie eighteen years; Jumla, twenty-five years. As bad as that sounds, they’re mining deposits assaying 2 or 3 grams per tonne on Earth! That’s why the price of gold has stayed so high; demand remains strong and terrestrial supply can’t match it.”

“The Uzboi ataxite is 1 gram per tonne gold,” noted Will. “But basically you’re saying that once you switch to the lower grade deposits, you’ll need close to four times as many people to maintain production.”

“Probably three times as many people, because we’ll use bigger machines,” replied Gerhard. “We’ll need to invest one billion redbacks per year in mining equipment over the next decade. We’ll also need four times the power supply because we’ll be crushing four times as much rock. Cassini, Dawes, and Meridiani will need a second reactor and a lot more solar panels. That’s why we’re arguing that Cassini and Dawes both need to double in size next columbiad. If Mars wants gold exports to continue, we have to have the people to do it.”

“But you’re not talking about suddenly doubling gold production, or that you suddenly need twice the people to maintain the existing production.”

“No,” agreed Bruce. “The gold production crew needs to increase about twenty percent to maintain production. But that means support personnel also need to increase a

similar amount. The rest is necessary to increase capacity. Cassini needs one hundred engineers and mechanics to design and build new machines; we're planning to locate the development facility there. Dawes needs twenty for its solar cell plant, because solar panels can provide a lot of the capacity we need. Dawes needs ten more for its spaceport. Both boroughs need another fifty construction personnel and additional capacity to produce housing units from the nickel-steel production of their PGM plants. Meridiani, Thymiamata, Kalgoorlie, and Jumla need similar increases. We'd also like to open a new outpost at the Alba Patera gold deposits. Add it all up and it comes to almost 2,000 people. You can cut it back somewhat, but then you need to invest more the next columbiad."

"We're hoping to bring six thousand immigrants in 2076, though," replied Will. "And eight or nine thousand in 2078. There will be plenty of personnel available those years."

"But at the price of some decline in production," said Bruce. "We can show you the projections if you want."

"I'd like to see the detailed report," agreed Will. "And the mining companies will pay for the immigration of their workers?"

"As always."

"Now, explain the infrastructure request to me."

"It's very simple," replied Bruce. "Moses plans to start constructing metal road surfaces between Uzboi and Aurorae in the next few months. We want a commitment to a metal road and accompanying pipeline between Cassini and Dawes right away; starting next year, ideally. The outposts are 2,300 kilometers apart. Dawes is also 2,200

kilometers east of Meridiani. From Meridiani, Kalgoorlie and Thymiamata are a thousand more. Dawes is the ideal hub for roads to both of them and to Jumla, 3,700 kilometers east of Dawes, so we want to see it receive early priority.”

“I understand that. But Uzboi is only 1,600 kilometers from Aurorae; they are the closest pair of large outposts. Uzboi has abundant nickel-steel production it needs to export, and it’s very heavy, so it needs a good roadbed. A metal road between them will provide fast transportation earliest and a pipeline will allow the largest outpost and the outpost that needs the most power to exchange power surpluses.”

“This is Aurorae bias,” replied Gerhard. “Whenever the Central Highlands outposts complain that something is going to Aurorae, the answer is always given that everything is already there, why spread it out! But we have pretty substantial infrastructure here, too; two Martech campus with important, specialized departments, very robust engineering capabilities, lots of electrical power, and more people than Aurorae had just five years ago! We even have pretty substantial buying power because the mining employees earn twice the average of other Marsian workers!”

“I’ll grant you, the Central Highlands have impressive capacities. But that’s partly because you have created this idea of ‘Central Highlands.’ The distance from Jumla to Dawes and then to Meridinai is as much as from New York to San Diego, with Cassini as far from Dawes as Miami is from New York. Together they have 3,000 people, which was indeed the population of Aurorae just a few years ago. But if you want to create a ‘Central Highlands’ others can create a ‘Capitol region’ of Uzboi, Aurorae, and Tithonium; maybe Aram and Thymiamata as well.”

“And you *are* creating a ‘Capitol Region’ with the metal highway from Aurorae to Uzboi,” replied Bruce. “But we’re funding Aurorae, remember; we’re Mars’s paycheck. And we deserve more recognition than we’re getting.”

“I agree with you,” said Will. “On the way back to Aurorae my flight stops at Thymiamata and I’m meeting with the mayors of Thymiamata, Meridiani, and Kalgorlie. If anyone needs a metal highway and pipeline, it’s the Meridiani area. They have scattered gold deposits, three outposts, and two permanently inhabited oases, but only one reactor. They need a pipeline that will send methane and oxygen around from Meridiani and the solar farms. If there’s any area on Mars that’s ripe for homesteading, it’s the Meridiani region; a family or two sitting at a small gold deposit could make a decent living if they’re on a pipeline and metal road that can bring them power, supplies, and emergency support. Moses needs to move one of the metal highway and pipeline laying systems to Meridiani, where we have a reactor to power a PGM recovery system. There’s a huge pile of nickel-iron meteorites there, recovered from the tailings.”

“And the road-building system could move to Dawes afterward?”

“No, Dawes and Cassini need their own. I’ll talk to Moses about placing the second unit at Meridiani. That’s a better allocation of resources. The road-building systems are expensive; they cost 300 million redbacks each and include over a hundred tonnes of specialized machinery imported from Earth, plus a year of manufacturing and assembly work by about 100 personnel in Aurorae. The pipeline laying systems are cheaper. We’ve ordered four road building systems and two pipeline paying systems; two of each arrive next columbiad and the other two road building systems the columbiad after. The road-building system lays 650 kilometers per year of roadway and pipeline; the

pipeline laying system installs 650 kilometers of pipeline. At that rate, it'd take two years to complete a road between Cassini and Dawes, working from both ends. Uzboi and Aurorae can be connected in two and a half years by one unit. The upgrade of the dirt highway between Cassini and Dawes, which will be completed this year, will allow automated driving at eighty kilometers per hour. That reduces the drive to thirty hours. The metal roadway would reduce it to maybe twenty-three hours; not much improvement. We will make the investment, but it is not a panacea. Cassini and Dawes are still as far apart as New York and Kansas City!"

"But so much of this is perception. We do feel slighted," said Gerhard.

"I think the Central Highlands haven't received as much investment as they could have. I'll support the effort to locate about half the immigration here; you do produce three quarters of our export income and its continuation is jeopardized by the decline in gold concentrations. Now, let me ask you another question, unrelated to immigration and development: what do you think of Ceres's declaration?"

"A waste of our resources," replied Bruce immediately. "They'll never support themselves."

"Oh, I'm not so sure," said Gerhard. "They're located next to a big ataxite deposit."

"So, should we be competing with ourselves for ataxite revenue?"

"Why not? We still haven't found a replacement for Uzboi. It'll last at least half a century."

"But we can be pretty sure there are other large nickel-enriched bodies here."

Gerhard conceded that with a nod, but Will asked, “Muller Mining is going into asteroid mining, isn’t it?”

Gerhard nodded. “We sure are. We plan to land an expedition on a near-earth asteroid. The caravel will have a built in carbonyl fractionation system. We’ll run it for 6 to 12 months, then return to Earth with at least ten tonnes of PGMs. Our system is based on the Uzboi equipment as modified for Ceres.”

“They have an experimental thirty tonne per day system,” said Will, “But that will make three tonnes of PGMs per year at most.”

“Asteroid mining is the wave of the future,” said Gerhard. “It’ll take some time for the technology to be perfected; a decade or so, depending on the investment. Uzboi’s disadvantage is that it’s at the bottom of Mars’s gravity well. It has the advantage of volume, gravity—which makes the process work better—readily available consumables, a permanent work force, and lots of nuclear power.”

“So, if Ceres has readily available power and a permanent workforce, it’ll be in a strong position?” asked Will.

“I think so. It even has gravity, which will help the process work. Its gravity well is so shallow, it might even be able to export cobalt and nickel to Earth. They’d have to be in huge quantities, of course, to make any money, but with fairly simple rockets that’d be possible.”

“That’s really interesting, Gerhard,” said Will. “I suppose if Mars wants to stay competitive with asteroidal mining, it should be involved in it as well.”

“Yes, I think so. You’re better off having the Uzboi engineers working on it. It’ll improve the technology for Uzboi as well.”

“That’s a brilliant point,” said Will.

“I’m skeptical,” exclaimed Bruce. “How much would Ceres need to export per year to cover expenses?”

“The annual operational costs are modest; fifty million redbacks to pay the salaries of the people on Ceres and the support people on Earth and Mars,” replied Will. “The space exploration plan we’re following, regardless of the status of Ceres, involves giving them a galleon, which is a billion-redback expense, plus fifty million more in salaries. It sounds like we need to invest a half billion or so in a special fractionation system.”

“I’d aim for 250 million redbacks of income per year,” said Gerhard. “That’s pretty easy to achieve; about thirty tonnes of platinum group metals per year. The Ceres ataxite is 320 parts per million PGMs, so that’s a processing volume of 100,000 tonnes per year, or 300 tonnes per day.”

“That’s not bad,” said Will. “Maybe five thousand kilowatts of power.”

“Which is the big limitation on a temporary asteroid mining venture,” said Gerhard. “That’s a lot of solar cells to haul to your destination. You also have the big problem of hauling 100,000 tonnes of ‘ore’ to the processor in zero gravity. Again, Ceres doesn’t have that problem; it has enough gravity for special wheeled vehicles.”

“This is sounding better and better,” said Will. “The argument that had made the most sense to me was that these are Martian citizens and they want to be under our jurisdiction, so let’s oblige them. But it sounds like there are economic arguments in favor.”

“Or at least the economic arguments aren’t all bad,” replied Bruce, still skeptical.

Will went back upstairs to his office from the Mars Council meeting, disappointed. As he came through Huma's office to his own, she looked up from her desk. "I gather it isn't going well."

"No. There's a lot of skepticism that Ceres might be a money pit. And the Supreme Court's ruling that this requires a Constitutional amendment doesn't help."

"It sounds like you have definitely swung to a 'pro' position."

"Oh, my conversation with Gerhard at Cassini last week did it. I hope he speaks up morrowsol. He was going to refine the numbers he threw out in our discussion." Will continued into his office and looked for a message from Helmut. Sure enough, there was one.

"Thanks for your videomail, Will. My big concern is Kurt. He seems to have taken a personal affront to our resolution. He is definitely opposed, which means Anne is as well, and as mayor of Aurorae and member of the Mars Council, she can be influential, I am sure. So we're biting our nails up here. While only 2/3 of us voted in favor of the resolution two months ago, I'd say the support for it is 90% now. I wish the Supreme Court hadn't ruled that a Constitutional amendment is necessary! You also asked about our PGM fractionator. As you probably know, the rated capacity is only 30 tonnes per day, and we've never been able to get it over 20. We were able to extract two tonnes of PGMs a year for three years before the war and since we restarted it two months ago, we've extracted 300 kilograms more. Lin Chen is in charge of the PGM system and he's been in touch with Gerhard every sol for the last few sols. They've been reviewing the various problems and he has fed the information to the Muller mining

experts planning their asteroid mission next year. I think we have a tentative solution for one of them, too. Let us know when we can talk to the experts at Uzboi. I know that's a political situation, though. The little I've seen of the Mars Council discussions is discouraging. Thanks for your help. Bye."

Will hit reply. "Glad to help, Helmut. I'm now behind this effort; I think Ceres has a lot to contribute to Mars. It won't be a one-way street. I plan to talk to some folks at Uzboi about their opinions and see what I can do to change their minds. I'll talk to Kurt and Anne, too. Bye." He hit send and stood up. Most members of the Mars Council would have gone to the Gallerie. "Huma, I'm going to the Gallerie to get a cup of coffee."

"Do you want me to get it?"

"No, I want an excuse to run into people."

He headed down the hall, down two flights of stairs to the entrance area, then outside to Andalus Square. The entrance to the Gallerie was just fifty meters across the cobblestones. It was 4 p.m.; too soon for supper, so the square was quiet.

So were the stores and restaurants of the Gallerie. But there were clusters and groups of Council members, sitting at tables or standing in circles and talking. He spotted Rodrigo Moreno, Mayor of Uzboi, and Carter Levine, one of the chief engineers for the PGM fractionation equipment, sitting at a table drinking coffee. Both were Council members; Carter was barely thirty, one of the youngest members of that body. After Will got a cup, he diverted over to them. "Can I join you?"

"Sure, Will," said Rodrigo, though he sounded a bit nervous.

“How’s everything at Uzboi? I just got to the Central Highlands last week, but haven’t been to Uzboi for a few months.”

“Well, you get to us a lot more often than you get to Cassini! Not much new; I think we’ll set a new record for PGM exports this columbiad, though barely.”

“How much?”

“Probably 1,080 tonnes. At ~~R~~250 per ounce or ~~R~~8 million per tonne, that’s 8.6 billion redbacks. Say, I hear Moses is putting one pipeline-laying machine at Meridiani instead of Aurorae; is that right? That’ll stretch out completion of the pipeline!”

“Well, we have a lot of pipelines to lay, and Thymiamata and Kalgoorlie need reliable power. A pipeline connecting them to Meridiani will do it. It’ll also boost gold production, because the pipeline can go past a dozen small gold deposits that can be mined intensively if power is available. We’ll finish the connection in less than five years, don’t worry. We’ll import more machines.”

“We’ve already made 2,000 kilometers of pipes!”

“I’m sure. Uzboi makes great contributions to Mars. What do you guys know about the various efforts to exploit PGMs in NEOs?”

“There have been two small bodies moved to L1 and disassembled and several tonnes of PGMs were extracted,” said Carter. “I’ve followed the work closely. They covered their costs. Muller Mining plans a mission to a Near-Earth Object next year and hopes to recover about twenty tonnes.”

“How long before someone puts a base on a NEO, rotates the crew, and builds up a major extraction effort?”

Carter looked at Rodrigo, who considered the question. “Ten years or so.”

“What will that do to our price?”

“I wish I had a crystal ball for that! The solar system has essentially an infinite quantity of nickel-iron. That’s not true of gold. On the other hand, every time the price drops, new uses arise. Just about everyone who extracted PGMs from terrestrial deposits has gone out of business because the price is now half what it used to be. Get us two more reactors and we’ll triple production and maintain Mars’s PGM income.”

“That’s probably what we’ll have to do. What do you think of your engineers becoming the experts in zero-gee and micro-gee extraction of PGMs? Then we control the technology, and the low-gee extraction technology doesn’t run ahead of Uzboi’s.”

“We’d need to expand our engineering team,” said Carter. “Are you talking about a permanent mission to Gradivus?”

“Or Ceres?” replied Rodrigo, catching Will’s implication.

“Ceres. If we add it as a borough, its ataxite reserves—which are at least half the size of Uzboi’s—effectively become Mars’s. It already is extracting PGMs. If the engineering team at Uzboi becomes its main ground support and we put money into developing better techniques for use at Ceres, all the terrestrial mining companies will want our help for their efforts. If they’re going to compete with us in PGM production, maybe they should be buying their technology from us.”

Rodrigo rubbed his chin. “That’s intriguing. The competition does worry me. I’m not sure what their expenses are, though.”

“Well, they’re a permanent outpost and they already have a facility, and we have already pledged to expand it, borough or not. That’s a pretty big subsidy of the PGM operation that a mining company doesn’t have. As for delta-v, it’s not bad from Ceres,

and they have plenty of propellant. They're probably the cheapest supplier of nickel-steel and cobalt for Phobos, so we certainly have to look into that."

"Delta-v to Mars is 2.7 kilometers per second, I think," said Rodrigo. "You raise an interesting point, Will. My natural concern is not to strengthen a competitor to Uzboi."

"So, do you think the operation on Ceres can cover its own costs? Let's say the costs are 100 million redbacks per year," asked Will.

"Yes, sure, with the right equipment," said Rodrigo. "That should be easy. We're producing thirty-four times that much per columbiad, about fifteen times as much per year, with 500 people."

"Let's say we want it to cover 500 million redbacks per year of costs, including missions to other asteroids. Could it also make a profit for Mars?"

Rodrigo laughed. "If we invest in it properly, of course. Put 500 people there and it could produce billions, just like Uzboi."

"And Uzboi's engineers will benefit, if you all develop the technology and keep improving it. What a fascinating partnership that could be."

Rodrigo laughed. "Actually, Will, I think you may be right. You're fishing for our votes, aren't you?"

"I am. There are several arguments for accepting Ceres, and I have gradually been convinced by them. One is economic; they won't be a drain on our resources if we invest in them, indeed, they can help us move humanity forward into space. If asteroid mining undermines the economics of Uzboi's work, we'll have Ceres. Another is the people on Ceres: they are Marsian citizens and want to remain so. They'll come back here after five or ten years and be replaced by other Marsians. A third is to look at our neighborhood;

we're the closest world to the Asteroid Belt in terms of delta-v. It's basically a vast archipelago of island-worlds. Ceres can be the central outpost there, the main reprovision point, and they'll get their provisions from us. And note that none of these arguments currently apply to Venus, Mercury, Callisto, or Titan. We're not talking about a domino theory, not right now. They don't have an economic basis."

"Not yet," said Rodrigo.

"Not yet. But it'll be decades before they do. The motivation for going there is still purely scientific and the support—both economic and political—needs to be international."

"But what if they develop an economic base?" asked Rodrigo.

"Then they achieve self determination, just like Mars has. Ceres is almost at that point, but they lack a critical mass of people. They get that by joining us. If Titan gets an economic basis but they lack a critical mass, they may want to join us, too. But we'll cross that bridge in several decades, not now. And then we'll have to decide what to do about them. But right now, we have to decide about Ceres."

"Yes, you are right," said Rodrigo. He nodded. "I think what you have said makes a lot of sense."

"Thanks. We'll need to convince the Marsian people, though, not just the Council. But I think we can. As the discussion continues, I think the arguments will become clearer." Will drank the rest of his coffee. "I had better get back to my office. Have a good sol, gentlemen."

"You too, Will." He rose, shook hands with them, and headed out of the Gallerie. He'd look for the Hollingworths later; he had to think about the arguments he had made.

“Come on, guys, Janus won’t wait forever,” said Johnny Lind. But his eyes lingered on the screen as well as they watched the live debate in the Mars Council.

“Rodrigo Moreno made a remarkable case,” said Marshall. “Who would have thought Uzboi’s representatives would support the Ceres resolution!”

“It doesn’t help us, though,” said Soo Kwok. “It was an economic argument, and we can’t make an economic argument, way out here.”

“No, that’s still impossible,” agreed Johnny. “The rings are pretty spectacular here, but I doubt there are many tourists willing to spend several years of their lives to come see them!”

“How many of us would want to be a borough of Mars, though?” asked Marshall. “This isn’t Mars, it’s Saturn.”

“But it would be a reasonable transition to an independent Saturn,” replied Adel. “I think all of us assume there will be an independent nation here some day.”

“I’m not sure why,” commented Johnny. “What is a ‘nation’? A piece of land defined by wars of conquest? We don’t have that. The territory of an ethnic group? We aren’t an ethnic group; we don’t even have a distinct culture.”

“Neither did Mars, thirty years ago,” replied Marshall. “But one evolved over the decades, including a Mars accent, which some of us are still speaking with here.”

“The kids have it, like yourself,” agreed Johnny. “I suppose we will develop some of that over time; local customs. But we’ll be dependent on the outside for a long time.”

“All the more reason to be a borough,” replied Marshall.

“What does your dad say?” asked Adel.

“He told me this morning when we exchanged messages that he plans to come out in favor of the resolution later this sol.”

“That makes sense; Moreno referred to their conversation.”

“So did Bach earlier today,” said Johnny. “He’s been working on people. Come on, EVA’s scheduled to start in an hour and we’ll never get outside by then at this rate. Let’s get going.”

“Alright,” said Marshall. He picked up the remote and turned off the television wall screen. Everyone stood up to head for the EVA preparation facility. Marshall headed to his room quickly first. He sat and recorded a message. “Hey dad. We’re on our way out now; our second EVA on Janus. This time we’re going to what appears to be the remnant of a cryovolcano, Rainier Facula. Since Janus is too small for cryovolcanoes, we’re either looking at a geological discovery or proof Janus was much larger in the past or a major misinterpretation of the geology. So we’re excited.

“We just listened to Gerhard Bach and Rodrigo Moreno. What a difference a day makes! I bet a lot of votes were swayed by their comments. Gerhard is so calm and steady, and has been on Mars since I was a kid; he’d very credible, I think. And if Uzboi’s in favor, who can oppose? Anyway, good luck with your statement. Bye.”

Marshall hit send and headed for the EVA suitup area.

His message flew from the *Santa Maria* on a beam of radio waves to one of Saturn’s four powerful communications satellites, where it rode a laser beam across the solar system to Mars, 1.5 billion kilometers away that day. When it arrived over an hour later, Will Elliott’s communicator vibrated. He was still in the Council chamber, which was about to take a one-hour break. He set the message on ‘text’ and skimmed Marshall’s

comments with a smile. He'd watch it later, so he could enjoy the face and voice of his son.

There was no time at the moment, though. He stood and looked around for the Hollingworths. Kurt could not speak in the gathering without special permission, and Anne had requested it. She was also on the agenda for later in the afternoon. They were speaking to Érico Lopes, who was a representative. He headed right over.

"I understand your concern, Kurt," Érico was saying. "This really does undermine the Asteroid Belt Commission. But the ABC has never had total jurisdiction over the Belt, anyway. There have been three national missions to the Belt since it was established and two more have been announced in the last year. The Commission's treaty specifies that the jurisdiction over an individual asteroid depends on who lands there, and the ABC has less than half the landings so far."

"Though more than anyone else," replied Kurt, interrupting. "Look, the ABC faces a difficult situation; practically any nation on Earth now can lease a caravel and head for the belt, plant the flag, and garner lots of national pride. But this resolution makes that problem worse, not better, Érico! It makes the ABC a joke! We have jurisdiction over asteroids no one lives on and a crew on one asteroid who have given their economic activity to Mars? What does the ABC's jurisdiction mean, in that case? It's an insult! It's ridiculous!"

"And what nation would give money to the ABC if all its crew become residents of a borough?" added Anne. "It'll convert the ABC into an agent of Mars! Maybe Botswana and Vanuatu will continue to give a hundred thousand redbacks a year and retain a tiny vote. So what?"

“The US, China, India, Europe, and Brazil have always had only token membership,” replied Érico.

“Kurt, what do you think would work to get more nations involved?” asked Will.

He turned to Will with anger and resentment in his eyes. “Nothing will now, even if this bill doesn’t pass! This has destroyed the ABC!”

“Not necessarily. Mars has always been the biggest pillar, but based on Rodrigo’s and Gerhard’s comments, a lot of asteroid mining companies could play a role instead. I think the ABC will have to adapt, but it sounds like it’ll have to adapt anyway.”

“Will, the ABC’s purpose is exploration of the Belt, not PGM extraction.”

“That’s not what the treaty says, Kurt. You’re right, the ABC has focused on exploration heretofore. But maybe the time has come for a shift.”

“So, Will, will Ceres become an economic engine for Mars, for asteroid belt exploration, for the entire solar system? What’s your vision?”

“I don’t have a vision for Ceres and may never have the chance to develop one; I’m not going to be Chief Minister forever, and the Ceres residents need to shape most of the vision. Kurt, what I see is someone who is hurt, and I can imagine I’d feel hurt, too, if my crew made a vote like this. But this is the new approach to exploration. If people are going to commit many of their years of their lives to a place, and their families, and their careers, they need to shape the community in that place and its future. This is a consequence of that trend, one that Mars started. The ABC can adapt to it and survive. Because it is still needed.”

“You’re more optimistic than I, Will,” replied Kurt. “Maybe Helmut should be Commissioner next. Because he clearly has fully embraced the trend you cite. It’s not my approach.”

“My friend, you can adapt to this,” said Érico. “Believe me, as the head of the Saturn Commission.”

“Oh, I believe you,” said Kurt, but he clearly had no interest in it. He and Anne turned away.

Will looked at Érico. “It’s too bad.”

“It is,” agreed Érico. “Kurt’s a smart, capable guy. But this is going to happen, and he needs to accept it.”

“You think the Council will pass this bill?”

“Yes, don’t you? I wonder what the folks on Titan are thinking, because we need international support a lot more than the ABC does!”

“That’s for sure. They know that, too.”

The Council resumed its discussions an hour later, and Anne Hollingworth was the third speaker. “I wish to speak against the motion,” she exclaimed. “My concern is simple: the Asteroid Belt is not Mars, Mars is not an imperial power, and asteroidal resources should not be going into Marsian coffers, not matter how benevolent we think we can be. I have no problem supporting the residents of Ceres via the Asteroid Belt Commission. This would be the right and proper way for us to support our fellow citizens who happen to be living on the dwarf planet outward from the sun from us. They are, of course, free to pass their own laws according to the powers stated in their basic law. Since such laws must be

in conformity with the laws of the country where the ABC is headquartered, they already have to be in conformity with ours. So, what do they really gain? What do we really gain? Should we seek profit from their resources? Should we assume their debts? Is it just a question of feeling good about ourselves because we now include the largest asteroid? Or is this really the best arrangement for everyone? Just because the people of Ceres think so, doesn't mean we must agree; indeed, we may even feel their assessment of what is best for them is not truly the best. If it ain't broke, don't fix it, and it ain't broke." She sat to strong applause.

"That's why she's mayor," observed Ethel, who had come to sit with Will in the visitor's galley.

"She's very articulate."

Lal Shankaraman called on Ichiro Otsu, the representative from New Tokyo and its mayor. "I am fascinated that Anne cautioned us against imperialism and then said we could decide whether the Ceres people know best about their own future. Three quarters of them voted for this, and I'm told that now pretty much all of them want to be an extraterritorial borough. They want our help with debt and want our help with prosperity. They want to tie their profits to us. This bill does nothing to undermine or weaken the treaty of the ABC. It can still be the funnel for development funds. It retains legal sovereignty over the land of Ceres. As we have heard, this arrangement does indeed offer all sorts of possible benefits for us, Ceres, and the entire asteroid belt, to which we are by far the easiest destination to reach. Our future is very much tied to exports to Earth and Ceres is an important chapter in that story. Let us embrace them and the future they promise us."

That also got strong applause. Lal called on Muhammad Rahmani, a Cassini representative, and he also spoke in favor. After two more speakers, Lal said, “That’s the sum total of the speakers. Who else wishes to speak?”

“I call the question!” shouted someone.

“Second!”

“Alright. Anyone else wanting to speak? No? Alright, will the clerk project the bill on the screen and read it aloud one last time.”

The Mars Council had elected a new clerk, Lyle Quincy, and he read it as quickly as he could, a task that took quite a while. Finally, Lal said, “Thank you. It’s time to vote. Please press the ‘yes’ button if you are in favor of the bill and “no” if you are against.” There was a long pause and everyone waited. Then the results flashed on the screen: yes, 42; no, 24. “The ayes have it, the bill has passed. As it specifies, we will have a vote on the Constitutional Amendment on January 3, 2073. I will entertain a motion to adjourn.”

“I so move!”

“Second!”

“It passes!” said Lal without waiting from a chorus of ayes. Everyone rose.

Érico hurried across the room to the Hollingworths. Anne was comforting Kurt. “I did my best.”

“Better that I could have.”

“Kurt, I’m sorry,” Érico said.

“But I bet you voted yes.”

“I did. I think it’s best, Kurt. And I think you can adjust.”

Kurt shook his head. "I'm resigning as Commissioner. I think someone else needs to tackle this challenge. It's time for someone new anyway; I've done it six years."

"I'm sure you'll find another challenge," said Anne.

"How about commander of the 2074 mission to Saturn?" asked Érico. "The two of you would be great for that flight."

They looked at each other. "Bill's 23," said Anne.

"Sounds like a good idea, Érico, but let us sleep on it," said Kurt.

"All of Mars seems to be celebrating tonight," said Mike to Will, as the family sat down to dinner. Liz had grabbed a lasagna at Deseret on her way home and had pulled it out of the oven a minute earlier.

"Yes, everyone seems to be in favor," agreed Will. "It's interesting how fast public opinion develops."

"It was a good debate," said Molly. "*Mars This Sol* carried a really nice summary, too. It's so much better than the debates in Congress."

"Oh, American politics; don't get me started," said Mike. "The Presidential vote still being counted, one day after the vote! Not to mention the attempted assassination of Senator Field and the real assassination of Congresswoman Lunt."

"And the two plots against President Mennea," said Will. "We can be thankful we're here. I'm afraid there will be another economic crisis because of politics. Consensuses never last long in American politics."

Ethel pulled out her communicator and looked at the *New York Times* website. "They still have Mennea as the victor, at least."

“I’ll send him a congratulatory message tonight,” said Will. He took some lasagna, then cut up Jason’s for him.

“Hey dad, I got a surprising videomail this morning,” said Liz. “Have you heard of Corey Kubota?”

“Corey Kubota . . . no, I don’t think so.”

“Zero-gee volleyball?” asked Mike.

Liz nodded and smiled. “That’s the guy. He’s been pushing to make it an Olympic sport. Otherwise, he’s a Canadian electrical engineer who’s spent parts of two decades on the moon and in low Earth orbit.”

“He’s legendary,” said Mike. “He wants to come here?”

“Yes, he’s trying to arrange a job on Phobos; he figures the best zero-gee volleyball players are there because there are so many people there and they spend so much time there. He called me because he was wondering whether the Aurorae Cultural Center might have funding. I haven’t called him back yet because I didn’t know what to say. He’s been advocating a zero-gee Olympics the year after the Winter Olympics.”

“Maybe we should do a Marsian Olympics the year after the Summer Olympics, then!” exclaimed Mike.

“Tell him to call Yuri Takashima,” suggested Will. “She’s coordinator of the Marsian Football Federation. It’s the most organized sport we have up here, and since the war they’ve gotten better organized than ever. They’d love to have a special championship series every four years.”

“That’s a good idea,” Liz said.

“Twenty-five years ago we were struggling to cover basic needs,” said Ethel.

“Now we can contemplate our own sports teams and competitions!”

“I think so,” replied Will.

They finished dinner and sat in the living room to watch television. About half way through their favorite show, Will’s communicator vibrated. *Mennea’s opponent just conceded*, texted Jacaranda. *Here’s the draft of a statement of congratulations*. Will read it, then stepped into Liz and Mike’s bedroom to tape a videomail. When he came back out, his communicator vibrated again with a live call. It was Jacqueline Collins. Hi Jacquie. Hold on a sec when I get some privacy.”

“Sure, where are you?”

“My daughter’s watching tv.”

“Oh, sorry.”

“Go ahead, I’m in the bedroom now.”

“Okay. There’s an email from Kurt Hollingworth to you, copied to several dozen national representatives, including me. He’s resigning as Commissioner of the ABC.”

“Oh, that’s really too bad. That didn’t take long; the vote was just four hours ago! But it was a really difficult situation for him.”

“I can imagine. We need a new Commissioner, and there’s one logical candidate, I think.”

“I agree: Helmut Langlais.”

“Mars has sixty-five percent of the vote on the ABC. Do you want to call him?”

Will considered. “Sure, I’ll do that right now. Kurt even said Helmut should be appointed. He understands the new situation Ceres is in and the new approach to space settlement.”

“He’s very experienced, too. With a staff here on Mars, he should be quite effective.”

“And we can be sure to get him the staff. Okay, Jacquie. What did you think of the vote?”

“I’m excited. It moves us toward the center of the solar system, in a way. Earth is still the real center, of course, but it’s so fragmented, it doesn’t function as the center.”

“Exactly. We’re in the position to settle the entire solar system in the next decade or so. We’ll have to talk tomorrow; make an appointment with Huma and bring Xiaopeng and Brian along.”

“Okay. Bye.” Jacquie hung up. Will searched his communicator for Helmut’s email address and recorded a message to him. “Good evening, Helmut. I want to call you to congratulate Ceres for the vote in the Mars Council this afternoon. I haven’t come out with an official position, but tomorrow I’ll make a statement and will be actively involved in convincing the Marsian public to vote yes. I think this will be a marvelous opportunity for everyone; a win-win situation. But that’s not why I called you. I was just informed that Kurt Hollingworth has resigned as Commissioner of the ABC. I didn’t hear an effective date, just that he has resigned. Mars wants to nominate you as his successor and third ABC Commissioner. Let me know what you think of that in the next twenty-four hours. Bye.”

He hit send and stepped out of the bedroom. The show had started again. “What did I miss?”

“She proposed to him,” replied Liz.

“Oh, I missed the good part!”

“What did you have to do that was so important?” asked Ethel.

“Oh, nothing. Congratulate President Mennea for his victory, receive the news that Kurt Hollingworth had resigned as head of the ABC, and call Helmut to ask him whether we can nominate him to serve instead.”

“Not much!” said Mike, laughing.

Will sat to watch the rest of the show. His videomail rode the interplanetary internet to Ceres, where it arrived a half hour later. Helmut was still in the upper half of a B-75 that the Ceres crew had converted into a gathering hall; they had decided to hold a fancy dinner that night to celebrate the vote of the Mars Council and had held it “outside” where they could see their world around them. A few parents had left with their smaller children—the 1.5% gravity was too low for small children to eat a meal very well—but everyone else was still present. Someone had taken a Marsian flag and had added a star to it and they all looked at it. Someone had even tried creating a Cererian verse to the Marsian version of “This Land is Your Land” and they all laughed.

Helmut’s communicator vibrated and he pulled it out. A message from Will Elliott. He had already sent a message of congratulations, so Helmut was surprised to get another message. He watched the videomail, surprised and pleased.

“What is it?” asked Adam Haddad, head of construction. He had leaned over and seen Elliott’s face.

“The Chief Minister just called to tell me—I suppose confidentially, so don’t spread it around—that Kurt Hollingworth has resigned as Commissioner. Mars wants to nominate me as the next Commissioner.”

“Really?” said Adam. “Fantastic!”

People applauded. “So, should I say yes?” asked Helmut.

“Yes!” bellowed the crowd.

“Alright, I will!” he replied.

14.

Steps Forward

December 2072

It was a fat, short vehicle, ten meters in diameter and sixty high, packed with 1,500 tonnes of liquid oxygen and kerosene and topped by a hydrogen tanker. It was built from the latest, lightest, strongest alloys and when it lifted off, it was pushed by nine of the most powerful and efficient rocket engines ever built. Early morning sunlight glinted off its silver sides and caused the word Prometheus to appear to flash. It rose from the pad quickly and disappeared into a clear, blue tropical sky. Long range cameras from around Kourou and in low Earth orbit transmitted clear pictures of the trajectory.

The crowd in the conference room on the third floor of the Commonwealth Building watched in tense silence. A second screen showed the control room at Kourou, a small, sparse place because the vehicle was fully automated. When the second-stage engines went out and word came that Prometheus 1 had achieved orbit, the conference room erupted in cheers and applause.

“Congratulations, Alexandra!” said Will. He hugged their chief vehicle designer.

“Thanks, Will, but Russian engineers did most of the work. They’re still the best rocket builders in the world.”

“They have the title back today, that’s for sure!”

She pointed to the bottles chilling in the ice bucket. “Our Chief Minister may not drink, but I think the rest of us can enjoy this champagne now!” She pulled out the

glasses and poured everyone their share. She had carbonated water ready for Elliott. They raised their glasses. “To our new shuttle!”

“Here, here!” They all drank.

“What a relief it went well!” added Yevgeny, ever aware of his responsibility to oversee the immigration of 4,000 people next year.

“It makes our schedule a lot easier,” agreed Jacquie Collins.

“How soon before we get one?” asked Huma.

“Even though this is the first reusable shuttle designed for use on two planets, it will require some modifications for Mars,” said Alexandra. “The first stage can put itself into Earth orbit without a second stage or any cargo and can be refueled to fly here, and its heat shield is robust enough to bring it to the Martian surface, but its nine engines are too powerful to launch it back into Martian orbit. We can remove four of the engines after it lands here and throttled back somewhat, they’ll be the right power for Martian gravity. A Prometheus second stage will have to throttle its engines back soon after launch to keep the acceleration under three gees.”

“How much capacity?” asked Huma.

Alexandra smiled. “The second stage, by itself, can put one hundred tonnes into low Martian orbit. The first stage will be able to loft five hundred tonnes.”

They all laughed in surprise and amazement at that. The Prometheus could put sixty tonnes into low Earth orbit and as such was one of the most powerful rockets ever flown.

“How many people is that?” asked Huma.

“Up to two hundred to low Earth orbit, 150 for now; at least as many to low Mars orbit for the second stage, and I’m not sure we’d ever build a 1,000-person cabin to put on top of the first stage!”

“We might have to, if immigration keeps increasing!” replied Jacquie.

“So, when’s the next launch?” asked Will. “Three weeks?”

“That’s the plan, and it looks like everything performed nominally,” replied Alexandra. “That interval will allow them to practically take it apart and check everything. The third launch will be ten days after the second, then launches will be weekly for a few months. By next summer launches every four days will be possible. The second Prometheus should launch in July, if everything goes according to plan, and it’ll probably come to Mars in the fall, depending on whether it’s needed to launch hydrogen fuel and cargo. Neither vehicle will be rated for human transport before September or October. We need to gain experience first.”

“Costs?” asked Jacquie.

Alexandra smiled again. “Better than we had previously estimated. The two stages cost 50 and 10 million redbucks to make and are supposed to be good for forty flights, though they can then be refurbished for about half that price and will probably be good for 100 flights. We’ll see. Anyway, take 60 million and divide by 40; that’s 1.5 million redbucks per launch. Add another half million for fuel and cargo loading and a million for turnaround inspections and routine replacements; that’s three million per launch. For sixty tonnes of cargo, that’s R50,000 per tonne or R50 per kilogram. For 150 passengers, including the cost of the cabin, it’ll be R25,000 per person. Costs here for the launch vehicle will be only 10 million because Prometheus second stage will be a single

stage to orbit vehicle. Propellant is more and maintenance is less because of the lower delta-v and gentler reentry. We should be able to launch to low Mars orbit for ₦10 per kilo with the second stage and ₦8 per kilo with the first stage.”

“A revolution in costs,” said Jacquie.

“Yet another one,” agreed Will. “We should be able to get people here for a quarter million each. A caravel between here and Mercury, Venus, Earth, or Ceres will cost maybe twenty million redbacks. Really cheap!”

“The planets will be knit together,” said Jacquie.

“Exactly. That’s why the priority needs to be settlement. Even the outer planets will be a reasonable price to reach. Heck, if the technology were reliable enough, we could send a complex of galleons on a thousand-year flight to Alpha Centauri!”

They all laughed. “We’ll have to leave that to another generation,” said Yevgeny. “Right now, I’m worrying about filling four galleons and six caravels with four thousand people and getting them here safely.”

“Well, if this thing keeps flying as planned, that has gotten a lot easier today,” said Alexandra. “I’m sorry the first launch got delayed so much.”

“It was worth it,” replied Will. “Keep it safe and make sure it works right, fix the bugs that will always be found, and give us the best, cheapest, most reliable launch vehicle ever built.”

“That’s what we intend to do,” replied Alexandra. “Give me three more months to wrap up our involvement in this, and I’ll be ready for my last design project before I retire.”

“The so-called ‘supergalleon’?” asked Jacquie.

Alexandra nodded. “We’re calling it the *corvet*. A bit more than twice the volume of the galleon, a sixty-two meter saucer able to transport 320 to Uranus, at least 1250 to Mars, a mass of almost 2,000 tonnes; quite a sleek, capable vehicle, and it should cost a billion redbacks with the lower launch costs to Phobos and that moon’s greater production capacities.”

Helmut got very little done, watching Charlie bound around on Lutetia’s gray surface. He was a member of a trio exploring north of the caravel *Wolf* and the view alternated among their helmet cameras, though usually the image came from Firuz Moulin’s camera, since he was in charge of the group. “We’ve got a really good sample here,” Charlie was saying just at that moment, and the camera zoomed in on an enstatite-chondrite sample plucked from an exposure in the crater rim. The three of them proceeded to describe the sample aloud. Helmut listened carefully, pleased by the insightful observations his son was making. “Yes, Massilia was the place to land, to get under all the regolith and find the bedrock,” said Firuz. “It excavated deep!”

Helmut touched his finger to a box in the lower corner of a screen in front of him. “You guys still haven’t reported any large chondrules,” he commented. “I’m surprised.” He touched his finger to the box again to send the message, which would take ten minutes to reach Lutetia. Coincidentally, two minutes later they

found an outcrop with large chondrules and proceeded to describe them.

No sooner had they finished the descriptions and took samples than they were called back to the ship. Lutetia rotated once every six hours; the sun was setting. Helmut

turned to his voicemail. He listened to a brief message from Carter Levine with a lengthy report attached. He read it, then hit reply.

“Thanks, Carter. The technical specifications look good to me, but I’ll check with Jack. Our experience makes it pretty clear that in Cererean gravity, fractionation towers need to be about twice as large as on Mars with the stronger fans we are proposing. It sounds like your towers might be made more efficient as well. The Asteroid Belt Commission still doesn’t have a Commissioner, so there isn’t anyone who can make a decision about this, but the logical plan is to import a thousand-tonne per day system that makes about 100 tonnes of PGMs per year. It’d use a third the output of a 15-megawatt reactor, the robotic ore-moving equipment will consume the same, and it’ll leave us five thousand for expanding the outpost. Our crops require considerable light supplementation, and the proposed fuel production facility needs about a thousand kilowatts in order to build up the hydrogen and oxygen storage facilities we’ll need to serve as a central transportation hub. Please begin to prepare us a mass and cost estimate. There’s no reason to plan a different size anyway, since you use thousand-tonne units and our modifications to your standard design may help improve it, anyway. Regardless who is Commissioner, this is the logical path to pursue. The next launch to Ceres from Mars is in March 2073, so we need to move. I gather the Commissioner will be finalized in one or two weeks, so we will be able to proceed officially at that point. Is that everything you need? You’re so interested in this project, maybe you should consider moving here! Thanks for your help, Carter! Bye.”

He sent the videomail. Most likely, Carter would reply right away; he was indeed fascinated by the project and was working extra hours to prepare a detailed plan for the Asteroid Belt Commission. Meanwhile, Charlie had sent him a message.

“Hey dad. What an incredible EVA! Adjusting to 0.05 gees was tricky, but I don’t think I fell much more than anyone else. You asked us about finding large chondrules; we finally spotted an outcrop with them about ten minutes after you asked. This place is mostly made of enstatite-chondrite with small chondrules, which suggests formation a bit farther out than Mercury, perhaps. Lutetia will be worth the three months, if we can collect enough samples and data to pin down its place of formation in the solar nebula. This is by far the biggest inner-solar system planetesimal that has survived, so I plan to write a senior thesis about it, even if I can’t wait until my senior year! Firuz said he’d be advisor, and he has faculty status at Martech, so we’re already talking about the data, what it means, what further research questions to consider, etc. I may have it written up even before I get to Martech for my Sophomore year! They also said they’d add my name to the list of authors; they’re already planning a series of articles for *Nature*. Anyway, we’re back inside now. We’ll eat and recharge our backpacks and plan tomorrow’s EVA. The regolith is mostly chondrite from the Massilia impact; there’s plenty of carbon and hydrogen here for an outpost, if anyone ever wants to set one up. The platinum group metals are fairly abundant and we hope to find spots with higher concentrations. Maybe this is the next spot for PGM recovery! We’re debating whether to raise a Mars flag here and claim it for that place as citizens, or let the ABC jurisdiction stand. Well, I better get going; I’m pretty tired. Talk to you later. Bye.”

Helmut felt a tear forming in one eye. He hit reply. "Charlie, I'm so proud of you. I watched the entire EVA. You did great; you participated as an equal, you dictated great descriptions, you participated in the discussion very intelligently . . . you sounded like a professional geologist. So rest, enjoy tomorrow's EVA, and start thinking about the courses you need to take to write up the best sophomore's senior thesis in history. You'll need some geochemistry and crystallography courses for sure. You'll probably be able to skip most of the field geology requirements! Firuz and most of the rest of the crew can advise you, even tutor you, and I dare say you'll arrive at Martech able to complete quite a few courses in short order. So rest for now, and let's talk tomorrow. Bye."

The orange ball almost seemed to glow. Marshall looked at the view screen in the bridge closely, its three-dimensional, full color image looking like a window, it was so perfect. They were closing on Titan. He felt a twinge of relief and a kind of home sickness.

"I missed this place," he said aloud to the other seven people seated in the room.

"Yeah, I did, too," agreed Adel, and he unconsciously rubbed his right hand and its two missing fingers.

"It's the people," observed Johnny.

"No, it's not just Amy and Willie, or the outpost; it's the world, too," said Marshall. "It's the place. Cold and dim and gray, but I still love it."

"That's a strong word!" replied Johnny. "And not very scientific."

"Well, you can't do good science without loving the subject," replied Marshall, and Adel nodded in agreement.

“I am looking forward to being home,” said Johnny. “This trip was hard on Tad. I wish he had come along.”

“But then you have to supervise his school work,” said Adel.

“At least he gets it done! He won’t be fit for anything without better grades! He wants to go back to his mother on Mars, but what can she do with him if he can’t get into Martech!”

“He won’t be the only Mars kid in that situation,” said Marshall. “Several kids have basically become bums for a few years, doing low-skill, odd jobs around the outposts. I think they felt they couldn’t match their parents’ expectations, which are pretty high on Mars. But most of them came around eventually and got their acts together.”

“Well, I’m not so sure about Tad! But I guess I was that way when I was seventeen, too.”

Johnny ended the conversation at that point because the computer announced the end of rotation. They felt gravity ebb away as the vehicle’s spin slowed, then stopped. They were ready for encounter with Titan’s upper atmosphere.

The encounter occurred just a few minutes later, a gentle push into their seats and a slight roaring sound as they encountered thickening methane and nitrogen molecules at ten thousand kilometers per hour. Gravity built up, then ebbed away and the caravel was just falling through the air, the pull of Titan’s gravity being rubbed off by air resistance. Rotation resumed and gravity became a complex combination of pulls. Unlike the seven minutes of terror that a Mars landing entailed, a Titanian landing was slow and long; it took several hours to pass through 900 kilometers of fluffy air. Terminal velocity at the

surface was a mere seventy kilometers per hour; the moon had so much air and so little gravity, a parachute was unnecessary. The engines came on briefly during the last few kilometers to slow their final descent and steer the caravel to pad 3, its standard landing place. Contact with the ground involved the slightest bump.

“Welcome home!” exclaimed Johnny. They all unstrapped themselves and stood. The control room’s floor felt tilted at a steep angle as a result of Titan’s perpendicular contribution to their weight. They headed slowly into the hallway where the other dozen inhabitants of the ship emerged from their waiting rooms. Everyone headed to their quarters to get their luggage and reassemble in the hub, where they could descend to the surface.

“Hey Marshall,” Johnny said as they headed to their rooms. “You did great on this mission. Your leadership of the science team made my work much easier. I appreciated the way you deal with troubles and misunderstandings. I’ll complement you to Yuri.”

Marshall smiled. “Thanks, Johnny, I appreciate that. I enjoyed serving under your command.”

“Thank you, I appreciate the endorsement; not everyone says that.” Then Johnny turned away and Marshall entered his quarters to grab his bags, which he had already packed.

The twenty of them gathered in the hub while the ground crew attached the heated tunnel and opened the hatch in the heat shield. Once the signal was received, five of them climbed onto the elevator platform and descended to the ground. Marshall was in the second group. From the ground level, they followed an oxygenated, heated tunnel

horizontally thirty meters, then descended a ramp into Acheron Outpost. A hundred meters down they reached the main tunnel, where a crowd awaited the arrivals.

“Marshall!”

“Amy!”

“Daddy!” They all called to each other at once, Marshall dodged around several other reuniting groups and hugged and kissed Amy and Willie at once. “Wow, Willie is so big!”

“When you’re away three months, it’s so noticeable.”

“It is! He was only up to here in October!” Marshall made a motion at Willie’s eye level. The boy laughed and grabbed his dad’s leg.

“Do you want to head home?” asked Amy.

“Yes, but I’d like to see Titanus Lacus, too.”

Amy laughed. “I wish people hadn’t dubbed it that! It isn’t finished, but we can stop by.” She pointed to a doorway down the main tunnel. They headed to it and entered South-3, where the environmental specialists had installed a lake and reed swamp in the last few months.

Warm, moist air hit their faces as they entered. The seventy by twenty meter space had a metal deck three meters wide along the front, then it gradually dipped downward into deeper and deeper water. Fifteen meters out a metal platform stuck above the water, then the color of the water changed, showing that the water became deep.

“There’s actually water underneath us here, too,” Amy said. “And we’ve installed grow lights; there’s no area of Titanus Lacus that is in complete darkness. This area here will be covered by sand and it’ll go all the way out to the island, which will be covered

with rock. There will be a net to prevent the children from going beyond, into the deep water. The sides of the enclosure beyond our swimming area and its far end have a zone half a meter to a meter deep that will be a marsh. Altogether, half this enclosure will be shallow water marsh for water plants and fish. Under the metal bottom of the marsh, though, is deep water illumined by grow lights. In effect, this lake is fifty percent bigger than it looks, in terms of environments.”

“Wow,” said Marshall, admiring the work. “Do you have all the species coming on the *Cassini*?”

“No! We keep developing our plans further. Right now we have a few species of grass that will grow in the water, rice, tilapa, fresh water microorganisms for our tilapa pond, and ducks. We’re not even sure what insects we have that will function here, and most likely we’ll have crazy swings in population when we introduce everything in a few weeks. We have a dozen more species coming on the *Cassini* and we’re in the process of ordering several dozen more for the flight in 2074. We’re also finishing up plans for a salt-water enclosure in 2075-76, for which we’ll need to import species on the 2074 flight. We’d like to make that enclosure twice as long, too.”

“A small sea,” said Marshall. “And when can we swim in here?”

“We’ll have the sand and rocks installed next week, then we’ll open it for swimming. It’s going to be a really nice addition to this place. One can even reserve it for private use.”

“It gets more and more livable all the time.” He looked around again. “Some murals would make the walls and ceiling more attractive. And the humidity is recycled?”

“Yes it’s condensed out and added to the irrigation system.” She pointed to the door. “Let’s head home. And Marshall, you’re now on *vacation*. That means no work for a while.”

“I know,” he agreed.

They headed back out of the enclosure and walked home to their flat on the *von Braun’s* court 5. About the time they finished unpacking, the *Victoria* landed safely as well, bringing the last of the mission back to Acheron.

Two hours later, a sumptuous celebratory dinner was spread out in the dining hall. Yuri again welcomed the crew back and praised Johnny for his leadership of the mission to three moons embedded in the ring system. “The caravels will be exploring Titan for the next three months, then they go out again to the last large moons in the system: Mimas, Tethys, and Dione,” he said. “This will be Johnny’s last command, because as most of you know, he and Tad will be returning to Mars next fall. Shortly we will announce what work areas will be moved from the galleons to the caverns so that the space can be converted to gravitied housing, because our population is increasing by nearly 100. Meanwhile, I have just heard today that the commander of the Saturn 3, which will leave Mars in July 2074, will be Kurt Hollingworth, former head of the Asteroid Belt Commission. Negotiations have begun for a second galleon to accompany him, one of which will be stationed here permanently.”

Yuri had the pause as applause erupted. “Who’s paying for it?” asked Sridhar.

“Primarily China, with some funds from India and the U.S.,” said Yuri. “If not 2075, in 2077 Saturn will grow to four galleons and potentially to a population of over 500 people. Indeed, we’re hoping to inaugurate a medical study to determine how much

gravity we need long term and how much gravitied space we can manage with, if the underground space is made larger. It may be that with four galleons, we can increase our population even higher. If we could grow Titan to about a thousand people, we suspect most people would be willing to stay much longer. Isn't that true?"

There was more applause and many people nodded. "Next year, also, we will acquire automated bases we can set up on all the major moons and on many smaller moons. Rovers and androids can explore and perform robotic repairs, and crews can reside temporarily. We will also acquire mobile facilities for androids operating on the Titanian surface. At that point it will be possible to dispatch missions involving only one caravel, keeping the other in reserve for rescue capability. In the next few years we'll have permanent presences on every major moon in this system. We'll also move toward excavating a series of small underground bases in several of the geothermal regions or areas with strong wind power around Titan so our human presence can expand across Titan."

There was applause for that announcement as well. "Hey Yuri, when will we discuss extraterritorial borough status?" asked Chad Sutton. His new wife Rose, who was pregnant, nodded vigorously.

"I don't know; what's your feeling?" asked Yuri.

"I think we should debate it. It appears Mars will invest millions of redbacks to expand PGM production on Ceres."

"I doubt they'll invest in PGMs here," replied Yuri, and everyone laughed.

"We're struggling even to find nickel-iron," commented Sridhar. "This world even lacks magnetic anomalies of any size."

“I’m sure we can find ataxite or enstatite chondrite if we make a major effort to search the entire system,” said Marshall. “It’s somewhere. But we’d have to set up a separate outpost to extract PGMs from it, it’d need a lot of nuclear power, and the cost of transportation back to Earth would be high.”

“In a few years, it’ll be lower than it was from Mars when gold mining started,” observed Sridhar. “But I agree. We have no significant exports. Mining Helium-3 from the atmosphere of Saturn is a century away and no one knows whether it’s even needed.”

“I think most of us consider ourselves Martian citizens, and we have great affection for the place,” said Ryoko Furukawa. “Some of us, like Marshall, are even native Martians. But the Mars Council has to consider politics and economics as well. We would be a huge financial commitment.”

“We have to consider the same,” agreed Yuri. “Mars provides only 35% of the Saturn Commission’s income. The U.S., China, India, Europe, and a dozen nations cover the rest. We want that to continue.”

That seemed to end the discussion, though Chad was scowling. There was a pause and Marshall said, “I have an idea that relates to this a little bit. We have occasionally commented about how we need to hold some seminars so that we can share our research with each other. I might hear about some of the ecological research by the environmental management specialists, but I’d like to hear more. There’s also the issue of sharing our results more widely with the academic community. We’re all publishing in journals, but we could be running distance-learning courses as well. So I wonder whether we should start a branch of Martech. It stands for ‘Mariner Institute of Technology’ not ‘Mars Institute of Technology’ after all, and we are all ‘mariners.’ It could sponsor informal

seminars, distance-learning courses, and the courses we need to run to maintain our certifications.”

“Brilliant idea!” said Yuri. He looked at Marshall with a new appreciation. “Okay, why don’t you pursue the idea, Marshall, and get back to us. I think that’s an important addition to our facility here.”

“And a good tie to Mars,” added Chad.

“Am I late?” asked Érico, hurrying into Jacquie Collins’s office. Xiaopeng Cai and Brian Stark were already seated at the conference table.

“No, they’re not here yet,” replied Jacquie.

“Good. I got into a long conversation with Yevgeny about the immigration situation.”

“There are new problems every day, and now they’ve found some potential problems with the Prometheus, but nothing they can’t resolve,” said Jacquie.

Just then they heard footsteps. A moment later Arthur Danforth, Jane Kohl, and Zhao Tao stood at the door. “Come in, come in!” said Jacquie, rising from her seat. She shook hands with both ambassadors and the American space representative. “Thank you for coming. Tea or coffee?”

They all agreed to tea; Jacquie and Xiaopeng prepared the cups while Brian Stark offered small talk. “So, Chief Minister Elliott has set the date for the election as Sunsol, October 18, 2073,” said Tao.

“Yes, the second Sunsol after equinox,” replied Brian. “It’s after almost everyone has left Earth orbit but before most have arrived here.”

“That makes sense,” replied Tao. “Has he said whether he will stand for reelection?”

“No, that wouldn’t be appropriate,” replied Brian. “The decision of chief minister is up to the Mars Council, not up to any particular individual.”

“We are allergic to politicians making empty promises, slandering each other, and bribing the public,” replied Jacquie, carrying the tray of tea cups. She passed them out. So, gentlemen, what do you have?”

“The United States will support the appointment of Helmut Langlais as Commissioner of the ABC,” replied Jane Kohl. “He is a citizen of Mars, Germany, and the United States, so we will consider him an American and appreciate that. We are not pleased that he supported extraterritorial borough status, but then, so did almost everyone else up there, and we agree with the Marsian approach to solar system settlements, in other words, that they need to make their own decisions about their priorities.”

“Thank you,” replied Jacquie. “We have only two more countries to hear from; everyone else has supported him as well. We’re also glad to hear you support the notion that these are settlements of professionals who are best situated to explore the planet or system where they are located and need to decide how to allocate the resources provided to them. Considering their isolation and the sacrifices they are making to go to their settlements, they need some respect.”

“One of those two countries is China, and we have no objection to Langlais,” replied Tao. “We only contribute five percent of the revenue and get five percent of the vote, anyway. But we do have a concern about this ‘settlement’ issue. If a nation sends a crew on a mission somewhere, they are its employees and naturally they must take their

orders from their home country. That has always been the case. We grant you that when the crew includes families and domestic matters like schooling and child care, the crew needs control over those matters, and if you're going to send a large contingent you need to make some provisions for the arts and continuing education. That's understandable. But that's not a rational argument in favor of semi-independence."

"We're not talking about rational reasons," replied Brian Stark. "These are cultural expectations, and they are never fully rationalized. The Mercury and Marsian revolutions prove that, and the Ceres and Saturn outposts have proved the effectiveness of this new model. Callisto has hardly been a good counter-example, either."

"As far as China is concerned, Callisto is working out fine," replied Tao. "It is an older and smaller facility than Titan. It is divided into two halves and the authority alternates back and forth between the two."

"It also has had a nearly one hundred percent turnover in staffing in six years," pointed out Jacquie. "Allowing them to have families there and decide more of their priorities will help immensely. The turnover rate on Titan, after four years, will be less than a quarter."

"Your galleon will help in that regard," said Tao.

"And it will soon be our turn to choose the next overall commander," added Jacquie. "By 'our' I mean the Americans and Marsians, of course. Charles Vickers is retiring and leaving when the galleon *Galileo* arrives; he will command the return trip of the caravel *Sagittarius*. The *Galileo* has made its maiden flight to Deimos. Quite a number of candidates were approved in time to arrive here from Earth last columbiad and the crew is now ninety percent complete."

“But still no commander,” said Tao, looking nervously at Arthur, Jane, and Jacquie, wondering whether they were going to drop a surprise on him.

Jacquie looked at Arthur Danforth; they had agreed he would tell Tao. “The United States and Mars have agreed on a commander.” He paused for dramatic effect. “Xiaopeng Cai.”

Tao looked at Xiaopeng, shocked. “I will do my best to bring everyone on Callisto together,” said Xiaopeng, in Chinese.

“Congratulations,” replied Tao in Chinese and English, uncertain what else to say.

“We think a Chinese-Marsian commander will help ease the transition to the galleon,” said Jacquie. “Callisto will grow from less than one hundred to over two hundred, thanks to the crew on the caravel *Gan De* that arrives with the *Galileo*. We will install H-75s, then move horticulture and labs out of the *Galileo* to provide additional gravitied housing. The two caravels on Callisto can be converted back into space transport, if desired.”

“And I suppose the crew that’s arriving will be able to elect a council,” said Tao.

“Of course,” replied Xiaopeng. “But not a commander, since Jupiter does not have a unified command.”

“And I doubt it will,” replied Tao. “I’ll report this development to Beijing, of course. I’m not sure how this changes our offer to provide forty percent of the cost of an additional galleon to Titan in return for a Chinese command.”

Érico spoke up. “That would probably be enough. That gets us up to ninety percent of the cost of an additional galleon, which would launch to Saturn in May to July 2074.”

“Mars can cover the rest,” said Jacquie. “And we won’t object to a Chinese commander to the flight. It will be up to the crew on Titan to decide who commands there, of course.”

“And I am certain that won’t change,” said Tao. “I’ll pass that on to Beijing. We’ll need to begin recruiting for that crew immediately, so they can fly here in time. We also want to provide a galleon to Callisto in 2076, and it will leave from Earth because the launch window from Mars occurs before the next immigration can arrive here. We want to fill perhaps forty to fifty percent of the ship and will leave the rest to the other partners, based on their contributions.”

“Okay,” said Jacquie.

“We can work with that,” added Jane.

“Excellent,” said Jacquie, looking around. “Anything else?”

“I don’t think so,” replied Tao, rising. “Thank you, Dr. Jacquie, for your hospitality.”

“Thank you for coming,” she replied, rising. Everyone shook hands, then the guests left. “So, how did that go?” asked Jacquie.

“He was not happy,” said Brian. “Arthur and Jane felt like appendages, too, and they didn’t like that role. This leaves the U.S. without command of any outposts beyond the moon.”

“But that’s temporary; we’re pushing to create an arrangement where commandship is based on merit, and the U.S. will get plenty of commands based on that,” said Jacquie. “What do we do about China?”

“I’ll make a lot of calls to people in Beijing,” said Xiaopeng. “They’ll put a positive spin on it to the media: the U.S. has retreated and China now has all the commands in the jovian system! But after parts of three decades up here, I’m an outsider, and that will be very difficult to overcome.”

“So, a positive outward face and a lack of cooperation?” asked Brian.

Xiaopeng nodded. “But let’s hope not!”

With China’s assent to Helmut Langlais’s appointment, the only holdout was South Africa. Jackie gave them a six-hour warning that 97% of the vote was in and Helmut was the overwhelming choice, requesting a decision by them immediately. When it arrived during supertime, the announcement of his appointment was immediately released. It reached Sebastian, Kristoff, and family at dinner in milliseconds, far sooner than it reached Ceres.

“Dad, you look like you’re going to topple over!” exclaimed Kristoff when he saw the shock on his father’s face.

“This wasn’t unexpected,” added Irma.

“So, Uncle Helmut’s in charge of the whole belt?” asked Mark, age 12.

“You might say that!” replied Sebastian. “He’s the elected commander of Central outpost, which makes him mayor of the borough of Ceres, now that it’s a part of Mars, and he’s Commissioner for exploration of the entire Asteroid Belt.”

“A commission that’s mostly ignored, since many countries mount their own national expeditions,” said Irma. “What did I hear the other day? Nigeria is launching a mission to an asteroid?”

“Yes, to be the first sub-Saharan country to do so; very prestigious,” replied Sebastian. “The Asteroid Belt Commission is rather powerless off Ceres, and now that Ceres is a borough, its role there is uncertain. That’s another challenge for him. Let’s videomail Helmut.”

Kristoff nodded and pushed a button on his tablet. “Videomessage to Helmut please, via the main screen,” he said. They all sat on the couch facing the screen, where the light turned green, indicating it was ready. Sebastian watched Mark and Nicola squeeze onto the couch with Irma; they were all ready. The recording would start once they started speaking.

“Greetings, Mr. Commissioner!” said Sebastian. “We just heard that you were appointed head of the Asteroid Belt Commission. What can I say? To say I’m very proud is inadequate.” Sebastian’s voice broke with emotion and he waited a moment before continuing. “What an amazing path you have taken, Helmut. What amazing opportunities have fallen into your lap. A charmed life, in a way. I think we all have lived a charmed life, in a way; Kristoff was just formally offered the rest of Ukraine yestersol, as we told you then. And I had my charms earlier, when I got to command Columbus 2. But your charms are just continuing! And this is a hard one. I found the ABC very frustrating to run, and who knows what it’ll be like to run an extraterritorial borough. If anyone can do it, you can.” Sebastian turned to Kristoff.

“Hey Sebastian, we are so, so proud of you, we’re ready to burst! It’s so exciting; I think Mark is ready to head your way on the first caravel that accepts him as crew! Too bad there aren’t cabin boys any more, eh Mark? Maybe he’ll be a Cererian geologist and

Nicola a horticultural specialist. At least we know you'll have a job here if you ever come back. We miss you and love you a lot."

"Congratulations, Helmut," added Irma. "We're looking forward to seeing Ceres grow and prosper under your leadership. I'm sure Amy's excited as well. We've been watching Charlie on Lutetia, too; dad's spent hours watching and sending comments. What amazing things our family's doing right now!"

"Good luck, Uncle Helmut!" added Mark, and Nicola chimed in with the same a second later. Then they all said goodbye and Kristoff sent the message. It flew a quarter of the way across the inner solar system and arrived at a celebrating Central outpost, where people were eating supper; Ceres had switched to Aurorae standard time two years earlier after an experiment with a "cere" equal to three Ceres rotations or 27 hours, 12 minutes that proved unnecessarily complicated. Tears formed in Helmut's eyes as he listened to the message.

"Thanks, everyone," he said in reply. "This is a huge challenge for all of us up here. We still don't know what it means to be a borough, let alone be the central outpost for the exploration of the asteroid belt! Dad, I want to talk to you privately morrowsol; I have a bunch of questions and need a lot of advice. This will take a lot of time; a lot of my time! But with your support, I can do it. Bye."

15.

Commander, Mayor, and Commissioner

Early January 2073

“It’s hard to believe 2072 ends morrowsol,” said Mike to Will, as they climbed the jungle trail in Congo enclosure to its top on Layercake Mesa. “It’s been a busy, crazy year.”

“More for me than for you,” replied Will, panting a bit as they power-walked up the 45 degree slope. He paused to look at an orchid growing on a tree, though it was really to catch his breath for a moment. “The solar system plan has taken on quite a life of its own, the idea of extraterritorial boroughs had all sorts of unexpected political and diplomatic consequences, and the plan to bring four thousand here next year has proved very difficult.”

“At least it’s spread out, with a galleon and four caravels heading to Venus and then Mars in two months with 1,200 people,” said Mike. He shook his head. “Who ever thought that would happen! And 1,200 more coming via Mercury in June! I never thought that would happen!”

“It leaves only 1,800 more for launch directly in the fall; a manageable number, especially considering we can use the moon for three separate waves this way, and use it for training as well as housing.”

“So, did you actually write that anonymous editorial about extraterritorial boroughs?”

Will stopped walked and looked at his son in law, wondering what to say. Then he smiled. “Yes, that was me. I’m not so sure it was a good idea, in retrospect! What do most people seem to think?”

“I think the Constitutional amendment will pass. The arguments are fairly simple and practical; if we invest a billion in Ceres over the next few annums, which we’ll do anyway, it’ll pay for itself and fund exploration of the Asteroid Belt. Or it should, anyway.”

“No, it will. Demand for PGMs on Earth has bounced back up and the price is back to prewar levels. Parenago is doubling its production as soon as they can get another reactor in line, and we plan to do the same. But the price won’t drop much because that’ll drive the remaining terrestrial producers out of business and increase demand for our product. And if the price were to halve, demand is estimated to triple anyway.”

“Wow; sounds like a guaranteed thing, or as guaranteed as anything can be!”

“Exactly. What other arguments are your friends making?” asked Will.

“Well, they’re Marsian citizens, so we are inclined to support them for that reason. I suppose the big worry is Magellan Station; if they want to do the same, would we support them, too? They have no resources.”

“And they’d be a constant drain; robotic equipment on the Venus surface never lasts more than a year, usually half that. The heat is relentless. Titan has decided against, but I suspect Magellan will hold a vote.”

“Mercury seems content with its current status, according to the people Liz and I are in touch with.”

“Yes, their expansion from 100 to 200 over the next four years, funded by the Europeans mostly, has made them happy.”

“And the plan to extract PGMs from a nickel-iron body one hundred twenty kilometers from Concord. More competition with us.”

“The market can bear it,” replied Will.

They reached the top of the mesa and looked northward over Congo, then Niger with its square and Serengeti’s agriculture beyond. To the left was Caribbean, then Mediterranean, both of which rose to the top of Layercake; to the right was Baltic South with its fir trees and ski slope, still bare of snow. Workers were putting final touches on a ski lift. Mike pointed. “That should be ready pretty soon, then people will use it to get to the top instead of walking!”

“Well, I’ll keep walking, I like it.”

“It’s amazing to see how much taller the trees are in here, compared to Baltic South.”

“It’s always warmer and wetter in here, and there’s never a winter, just a dry season. I’m amazed they managed to stuff so many trees in here between the boulders! They moved the rocks around to create giant soil pockets.”

“Very natural looking. There are trees in here five meters high already, but they’re barely three in Baltic South.” He pointed. “Do you want to go down there?”

Will shrugged. “Sure.” They headed to a tunnel concealed in the cliff nearby. It took them to a pressure suit donning facility, which had another tunnel connecting to Baltic South. When they stepped into the other enclosure, they shivered. “Chilly.”

“We’re just about a month past autumnal equinox, so it’s late October in here,” noted Mike. He pointed. “The birches turn a pretty yellow this time of year.”

“The maples on the bottom will be bright red in a week or two,” agreed Will. They started down the winding trail. “So, should I say anything more about the amendment?” persisted Will.

Mike stopped, surprised his father in law sought his advice. “I think you have made the case. The economic and social arguments have been made.”

“I suppose I need a new, good idea if I want to say anything else.” Will changed the subject. “How’s research?”

“We got the paper about magnetic anomalies on Thaumasia done,” Mike replied. He chuckled. “Do you want to hear something surprising? Ken Leonard, one of the geologists on Ceres, emailed Geophysics yestersol seeking partners to study Ceres paleomagnetism.”

“Really? They’re pulling out all the stops up there to generate research!”

“They are, and this is a good project, since Ceres may preserve evidence of the solar magnetic field at the time of formation.”

“Ah, that’s a good research topic, then. But you aren’t planning to go there.”

Mike laughed. “No, Liz would be very unhappy! But we can help their research with our supercomputer, and I may join that team. Martian paleomagnetic research is getting stale.”

“Yes, Liz can’t dance anywhere else in the solar system as well as she can here.”

“And she loves the cultural center job. It’s perfect for her. We can’t take Jason and Shayda anywhere for at least fifteen years, but that doesn’t mean I can’t tackle problems with collaborators elsewhere. I’m still doing work on Mercury, after all.”

“That’s right, you are.” Will sighed. “I’d like to get back into geology.”

“You still have time,” reminded Mike, with a smile. He wondered what Will would say, since he, like everyone else, wondered whether he’d run for office in 2074.

“Yes, I suppose I do,” replied Will.

They reached the bottom of the slope quickly. They headed across the marsh and into Baltic. Crossing the square to the public transportation center, they encountered Dr. Nigel Stanfield. “Good sol, Nigel!” exclaimed Will. “So, when are you heading to the South Polar Station?”

“Two weeks,” he replied. “It’s great the Americans have reopened it and are funding it again. This year we have a comparative research grant with a team in the Antarctica, too, looking at the mechanical properties of ice caps.”

“A good topic,” said Will. “I’m glad they followed through with their pledge. Good luck with the trip.”

“Thank you. By the way, we also got an email from the Ceres geological team proposing some comparative research with the Cerean—or is it Cererian?—north polar cap.”

“Cererian; it’s from the Latin adjective. It’s amazing how many research projects they’re starting up there!”

“It is, though it’s too bad a twenty-first century English adjective has to be derived from a language that’s been dead over a thousand years! We may take them up on

the idea next fall, too, when we're back from the station. They have a lot of layering of snow and regolith there, and lots of frozen carbon dioxide trapped in it, so there are a lot of parallels. Ciao."

"Ciao."

Mike and Will headed to Andalus, where Will went to his house to shower and dress for the day. Meanwhile, on Ceres, Helmut finished his hour-long workout, showered, and headed for his office next to the *Piazzis*' control room. He had a pile of videomails to send and receive. He was pleased to see that Érico Lopes had responded by email: *Titan would be glad to sell you nitrogen. We could fill a Hermes with one hundred tonnes of liquid nitrogen and send it on a three-year trajectory to Mars, where a gravity assist and engine burn just above the Martian atmosphere could put it on a Hohmann trajectory to Ceres, where it would arrive fifteen months later. Total travel time, fifty-one months. The price will be the same as buying it from Mars if you can refuel the Hermes and send it back to us.*

He hit reply. *Good price and we want to support our fellow settlement, though 100 tonnes may be a lot for us. Yes, we can send the Hermes back; what can you buy from us? I'll send a list of possibilities, then we can draw up a contract.* He hit send, happy.

Carter Levine, Uzboi's chief engineer, had replied overnight as well so he played the videomail. "Morning Helmut. The stronger fan seems to have improved your throughput from twenty tonnes per day to twenty-seven, so we're getting closer to the thirty tonnes per sol the equipment is rated for. Jack was pleased. I talked to our chief geologist, too, and he confirmed that your ataxite body should have spots that are at least fifty percent richer in PGMs than average. That's true of our ataxite, but we take the

whole thing, crush it, and fractionate it, because we have such a big operation. You should be able to push up production by concentrating on the richest spots. He's sending Jack a series of technical memoranda about the matter.

“Finally, one more thing. I'm thinking seriously of putting in for the flight to Ceres next year if the position of chief of production is available. I gather Jack is wearing several different hats right now, and he seems willing to let someone else run the ataxite operation. What do you think? Bye.”

Helmut pondered that a moment. Carter was very bright and creative, but also ambitious; he was on the borough and Mars Councils. But that couldn't stand in the way. He hit reply. “Good morning, Carter. We would be delighted to have you come here! I'll talk to Jack further about the matter, but we are expanding, so there will be new positions, and I think I may be able to accommodate his skills and seniority in other ways. The plan to add an inflatable ‘capsule’ to the caravel increases its transport capacity, too, so we're still recruiting. I am very impressed by your assistance with our systems; it appears you may manage to push us up to the theoretical maximum production, and maybe beyond! Every sol, it's looking better and better for Central Borough and its future. We're very grateful. Please talk to your wife and consider the possibility quite seriously, and let me know. Bye.”

He sent the message and turned to a new one from Quentin Pauwels, a Belgian astronaut who had worked at Parenago on the moon, spent two years at Concord Station at Mercury's north pole, two years at Magellan Station in Venus orbit, and two years on Mars. He now worked for the European Space Agency, but he and Helmut had been going back and forth since Helmut's appointment as Commissioner two weeks earlier.

Helmut hit play. “Good day, Helmut,” Quentin began. “We definitely need to offer the option of sponsoring a lander with minirover; just about any country can afford that if they are mass produced. I suggest you add the option of sponsoring one or more astronauts to an exploratory mission. That’s an easy, cheap option to offer; maybe two million redbacks. Quite a few countries will see that as a stepping stone to building a small space program, which might lead to leasing a caravel and sponsoring an entire mission to an asteroid. I’ve attached a list of countries I could approach for you, categorized by type of project. Shall I proceed? Bye.”

Helmut opened the document and scanned the list; it had seventy-eight nations on it, ranging from Belgium and New Zealand sponsoring an entire mission to Tuvalu and Lesotho sponsoring an astronaut. Small countries like Singapore that had good universities were listed as possibilities for sponsoring a lander/rover. Helmut hit reply and attached a revised fact sheet about the lander/rover.

“Good sol, Quentin. Yes, you’re hired! I’m glad our discussions have reached a conclusion. Send me the contract, signed, and I’ll send back a copy signed by me. I think I’d like to tape the opening videomail listing the possibilities and introducing you as the ABC’s agent. I’m also attaching the revised fact sheet about the lander/rover. This is quite a big revision, so review it carefully. Martech sought advice from both JPL and several European contractors. The mass of the minirover is down to 100 kilograms, but the science lab on board the lander is up to 150 kilos. The minirover’s range can be two kilometers with the new batteries that are proposed; farther, if one tolerates the low power available from the solar panels on board. The lander will carry a tonne of argon for its ion engine and a tonne of methane and oxygen for take-off, landing, and hops across the

asteroidal surface. The carbonaceous chondrite processing unit will mass about 100 kilos and should be able to manufacture a tonne of methane and oxygen over a year's time. These units won't be cheap; maybe fifteen million redbacks. But one of them should be able to operate for ten years and visit as many as ten asteroids, and it should be reusable. If we could get a half dozen nations to sponsor them, we'd have a robust exploration effort and lots of data for manned missions that could follow. We'd need a crew of maybe twenty on Ceres to operate them; nations could sponsor those positions, too. I'll try out the script we've agreed on and copy you. Bye." He hit send, very pleased that Pauwels was hired. Everyone said he was good.

He noted again that Belgium was on the list of potential mission sponsors. His father was old friends with the head of the Belgian space agency, Dr. Pierre Dumont, and had told him to be in touch. Furthermore, Dr. Dumont had sent him a congratulatory message. So Helmut pulled up the script, made a few modifications, and recorded a message.

"Good morning Dr. Dumont. Thank you again for your kind message last week, wishing the ABC every success. I have plunged into the work right away and we have developed a range of ways that nations can pursue their space exploration efforts in a coordinated fashion through the ABC. You may have heard of our first notable success: Nigeria had already planned to launch a caravel to the Asteroid Belt next year, primarily to set feet and flags on the asteroids Lagos and Abuja. They still plan to do that, but they will also stop at Ceres, where we are offering a free propellant refill and consumables at a reduced price, and from there they'll go to Juno, a major body badly in need of

exploration. Free propellant and readily available consumables at competitive prices are now a standard policy; any mission visiting Ceres will get them.

“And I hope Belgium will consider mounting its own mission to a series of asteroids in the belt. A caravel can be leased and stocked for an up-front cost of one hundred million redbacks. Propellant is a small additional cost. Crew and support salaries will add perhaps fifty million more per year. Hence a five-year mission will cost 360 million, spread over six or seven years; an average of less than sixty million per year. If some of the fifty berths are contracted out to other nations, your mission will cost you even less. We’re looking for missions that will go to Eunomia and Hygiea. The latter, in the outer belt, is the fourth largest asteroid and the largest carbonaceous asteroid and is a high priority. You have geology departments at several universities that could provide support for the mission. It can be launched from Earth or Mars; we are not worried about that.

“Please let me know if you need additional information. I am copying Quentin Pauwels, representative of the Asteroid Belt Commission on Earth, so he can follow up in person if that is of any assistance. I’m sure you know him, since he is Belgian. We hope to work with you. Thank you and goodbye.” He reviewed the recording once and hit send. He doubted the Belgians would respond, but it was worth a try.

A message from Will Elliott popped into his box. The Chief Minister was up and at work. Helmut hit play. “I spoke to Jacaranda and what sort of publicity campaign you should carry out on Mars and Earth, and got input from Pete Theodoulos as well. Feel free to contact them directly; I gave them permission to be in touch with you directly. I’m glad I was able to coordinate your contact with them. Jacaranda said that anything you

write or record for the Marsian public should stress practical matters and facts; the public is sensitive to exaggerations. But they'll also respond emotionally to arguments like you're fellow Marsians, so those are worth stating. I'm attaching our talking points; they're reflected in my statement you can see on *Mars This Sol*. I also forwarded to Pete and Ruhullah your terrestrial strategy document, and they were both impressed, as was I. Kurt didn't have the personality to sell things via videomail to strangers on Earth. I think you'll be much more effective. So, how are things going up there? Feel free to inform me if you wish. If there's a decision to be made, run it past one of my colleagues first, and they'll ask me if they need to. I'm trying to delegate more; I won't live forever! But I need to be in the loop. Bye."

Helmut smiled at that; it gave him the permission he needed to keep Elliott informed. He hit reply. "Good sol, Will. Thanks for the permissions. I saw your piece on *Mars This Sol*. I'll restate the facts—you gave them elegantly—but focus on our status as fellow Marsians and our common vision for the future of the solar system. Overall, things are going well. Thank you for the referral to Quentin Pauwels. I just hired him and we're starting a series of communications with national space officials. We're following Jacaranda's recommendation that I make the initial contact. Please thank her for her advice about the talking points and the tone of my communication. Pauwels is charging us a huge salary, but he'll be worth it. We have a team here, on Mars, and on Earth filling in the details of the budget you've given Ceres for the next annum, and we'll give you a recommendation for the annum after as well. That's the latest. Bye."

He sent the video message and it winged its way to Mars, where it popped into Will Elliott's inbox. He was in the middle of a meeting reviewing the immigration effort,

which had the usual last-minute hitches, but when it was over he went back to his office and listened. “Helmut says thank you for your help,” he said to Jacaranda, who stepped into his office just at that moment.

“Oh. Good. He’s a natural communicator, just like you. He doesn’t need much advice.”

“Yes, he has jumped into his new roles immediately. I’m impressed. So, what do you have?”

“An interesting development on Earth. The White House has called for a new United Nations charter conference. They said that the Grand Union’s growth is slow and has to be slow because of the need for legal and fiscal coordination, which will take at least a generation in many places, so the need for the United Nations remains. But the United Nations requires considerable reorganization to account for ‘late twenty-first century conditions.’ They listed a dozen examples; one was ‘trusteeship over the settlement of the solar system.’ I’m not sure they want to gang up on us or support us.”

“It certainly means we’ve raised some issues, and I think that’s good.”

“The press statement also mentions as an aside that Mars should join the U.N., so they do have us in mind.”

“Really? That seems surprising. Ask Huma to ask Pete to inquire about it. Send me the statement, so I can read it, too.”

“Okay. We may want to comment about it.”

“Even support it. The solar system needs a better legal framework. Thanks, Jacaranda.”

She stepped out and Will turned back to his screen. Marshall had videomailed him, so while he was waiting for the White House statement, he opened it.

“Hi, dad. I just got back from a four-day trip to Sotra Facula. It was our second and we’re already planning a third trip, to explore the northern flanks. What a huge volcano, and it’s still quite active! It’ll definitely be the site of our first base, using geothermal power to keep the place decently heated. We think we’ve found a spot that is central enough to give access to most of the mountain complex, but stable and safe.

“I don’t know whether you heard, but in consultation with Yuri Severin, Martech just appointed me ‘Chancellor of the Titan Campus of Mariner Institute of Technology.’

Yuri has given me a two month leave of absence from my geological duties to get it organized. We’re already talking about forming departments, and I have to negotiate further with Martech about transferability of status and the benefits that result.

Meanwhile, yesterday the head of Mercury exploration at Concord Station contacted Martech and asked about forming a branch campus there once they expand, and last night I got an inquiry from Xiaopeng about our plans, because he wants to implement the same on Callisto! I’m thrilled. This is one big common institution all of us in space can share.

We all need a university; we can’t survive here without advanced training. Some of us up here in space are astronauts, some are cosmonauts, some are taikonauts, some are members of the Mars Exploration Corps, and some are just specialists. But we’re all *mariners*, if I may use that venerable old word that way. I’m sure Enlai and Martha had that in mind when they named a university after Valles Marineris, which in turn was named after the old Mariner series of interplanetary probes.

“Anyway, I now have a mission: organize a campus! Just about everyone up here is qualified to serve as faculty. Yuri has said that we can devote ten full-time equivalents to teaching, mostly online courses, so we will have to rotate that among a very large number of people, mostly geologists and ecologists, though the engineers want some slots, too. We’ve already been offering thirty online courses per year through exiting universities, so now they’ll all be pulled together and coordinated under a single name. And when we expand next year, we’ll have even more resources to contribute to human knowledge. Ideas welcome! Bye.”

Will watched the image fade. He ignored the White House statement that had popped into his inbox or his pride in his son. *Mariners*. That was the word he needed. They weren’t just astronauts, cosmonauts, taikonauts, and various mission specialists; they were everyone in space, young and old. Mariners.

New Year’s 2073. A great crowd filled Andalus Square at 12:37:22 p.m. on December 30—Marsian months never had 31 sols, because of their greater length than the terrestrial day—and celebrated as the new year began. *Mars This Sol* automatically updated some of its news features, and among them was the Chief Minister’s greeting for the New Year.

“This will be a crucial year for exploration of the solar system,” Mike read aloud the next morning to Liz, for he was so enamored of Will’s statement. “Marsian citizens go to the polls in two sols to consider a modification of their Constitution to allow extraterritorial boroughs, a change with unpredictable long range consequences. In February, the first of four waves of immigrants—roughly a thousand each—will set out for the Red Planet, augmenting its population by more than a third and bringing a dozen

new personnel to Magellan Station. In March a caravel sets out for Ceres to increase its population by fifty and the caravel *Wolf* will end its exploration of Lutetia. May will see the launch of an American mission to explore the near-earth asteroid Eros. June will see the second wave head for Mars; when they pass Mercury they will drop off forty new personnel for Concord and pick up ten heading for Mars. In September the *Cassini* reaches Titan and expands the human presence in the Saturn system by a third. In October, the third wave of immigration to Mars leaves Earth on a six-month direct flight. In November, the first wave arrives at Mars and the vehicles turn around to fly straight back to Earth after a month's stay. In December, the fourth wave departs Earth, to arrive here five months later. Preparations for the June 2074 launch of a galleon and a caravel to Callisto and the July launch of a galleon to Saturn will be well underway and plans for the first Uranus mission in 2078-80 will be assuming final form.

“Almost every planet in the solar system will be touched in 2073. The rest of the decade will see as many as a dozen missions to asteroids, three more to Saturn, three more to Jupiter, the arrival of three or four very small asteroids in Venus orbit to provide the station there with an anchor and resources, an expansion of Mercury to at least 200, and the launch of several hundred people to Uranus. Mars will expand to several tens of thousands.

There will be a great maturation of societies off Earth and the evolution of common institutions. In the last month, Martech has planned its first campus off Mars, at Acheron Outpost, Titan. Similar branches are under consideration in two other locations. Our university may become a common institution, from Mercury to Neptune, some day. Economic, social, cultural, and political ties will grow and collaboration on common

projects will spread. A new identity may very well emerge, a *mariner* identity, from the coldest worlds of the system to its hottest inner member.

“For we are all already mariners, just like the early mariners of old who set out to explore the Earth’s seas and seek new lands and opportunities. From Mercury to Saturn, a mariner culture has begun to take shape, multicultural and multinational from the point of view of Earth, and diverse within its own ranks because of the different circumstances surrounding each settlement. Exploration is one of its defining characteristics. The culture is evolving at different paces at each place on this vast archipelago, with the influences spreading through migration and the interplanetary web. It is a culture with remarkable low-gravity sports and art, new fusions of science and literature, distinctive patterns of community organization, a pragmatic approach to problems, an appreciation for facts over spin, a commitment to individual creativity, an abiding trust in collaboration and team building, and a profound optimism that the future will be bright. It is a culture conscious of itself and able to debate the shape it will take. The year 2073 will see it assume a distinct form, and all of us can contribute to it. Let us dedicate our lives to its steady advancement.” Mike put down his tablet. “Wow! I thought I was a Marsian, but now I find out I am also a Mariner!”

“By the way, dad didn’t coin the term; Marshall did, accidentally,” said Liz.

“Still, your dad’s the one who defined it for all the world. And he is right; from Mercury to Saturn, we do share a culture with many common characteristics.”

“The low-gravity sports —especially various forms of volleyball—is definitely true, and the call for a zero-gee Olympics reflects it. Mercury and Titan want to start arts centers, once they expand, and the Uranus team has already contacted me about how to

include an arts center from the start. He could have mentioned horticulture because it shares a lot of commonalities, too. There's a lot of collaboration. We still don't share very many distinctive songs."

"I'm sure that'll happen. These seem like trivial things, but together they create identity, and that's a powerful thing. Exploration: that's our driving value, too. It gives us a sense of purpose that terrestrial societies lack. But still, I don't see the Marsian Commonwealth becoming the Mariner Commonwealth."

"Maybe not; that involves more change than just a few letters. But perhaps a Mariner League or a Mariner Union . . . who knows?"

Mike nodded. "Perhaps that could happen in a decade or so."

16.

Constitutional Amendment

Early Jan. 2073

When the clocks in the great room of the *Piazz*i rolled over to midnight—24:37:22—half the adults of Central Outpost turned anxiously to watch the *Mars This Sol* website, which was broadcast live onto the screen. When the results of Mars’s constitution referendum flashed onto the front page, everyone cheered.

“Five to one: they want us!” exclaimed Adam.

“Well, most of them do!” quipped Jack, who loved a good joke. “We’ll send the rest to Callisto!”

“Let’s sing!” suggested Rahula Peres, and he started:

*This land is your land, this land is my land,
From the Hellas Basin, to the cratered highland,
From Tharsis Montes to the Mariner valleys,
This land was made for you and me.*

Then he spontaneously added:

*New borough Ceres, dwarf planet settling,
Ice mantle drilling, PGM mining,
An Asteroid Belt forever exploring
This world was made for you and me*

Everyone laughed and sang along with him, then laughed again. “We’re definitely a borough now,” exclaimed Helmut. “We’ve got our own stanza! Someone grab the audio and video and upload it to *Mars This Sol*.”

“Can we break out the champagne?” asked Juliette.

Helmut nodded. "Sure. Morrowsol is a Ceres 'national holiday' shall we say. No one works on January 4 from now on."

Juliette pulled out six bottles of champagne while Adam found the glasses. They poured 30 glasses and everyone raised theirs. "To Ceres!" said Helmut.

"To Mars!" added Rahula.

"To all Mariners!" added Jack, for Elliott's New Years statement has been widely read and commented on at Ceres.

Helmut's communicator buzzed. He pulled it out; a message from Will Elliott. Helmut retreated to a corner of the room and hit play.

"Welcome, Mayor Helmut and welcome to all of Ceres! Mars has embraced you. Congratulations to Central Borough. We look forward to your participation in the Marsian endeavor for as long as Ceres wishes to participate. Everything suggests that Ceres will pull its own weight and much of the weight of the entire Asteroid Belt and will enhance the capacities of Mars. As a borough of Mars, Mars will now provide Ceres with a safety net and will enhance your capacities as well. No one knows where this partnership will lead, but we can be sure that it will foster the advancement of science and exploration, strengthen civilization, and further the mysterious purpose of humanity. Therefore we welcome you with great joy. Best wishes to you and everyone in the borough."

Will Elliott's face faded from the screen. Helmut smiled and hit reply. "Thank you, Chief Minister Elliott! Ceres thanks you for the warm embrace. We pledge you our loyalty and appreciate your support for our endeavor, just as we will support yours. Central Borough must be the largest borough in terms of area, but it is smallest in terms

of population. We look forward to growing and participating actively in the exploration of the solar system. Best wishes to you for an exciting and productive 2073.”

A huge cloud of dust rose within the southern end of Mediterranean Enclosure. “What’s that?” Will asked Ramesh, pointing. They had just entered Mediterranean.

“We had to add more regolith to the talus pile because more was sifting between the boulders than calculated. That dust plume looks worse than it really is; a hose is spraying water on it. A temporary plastic barrier is keeping the dust from spreading to the rest of the enclosure.”

“The talus pile has proved the toughest part of every enclosure to close off. Did you hear about the eruption of salty, sulfurous water in Baltic South last week?”

Ramesh chuckled. “Yes; it flooded the marsh with an extra meter of salty water and killed everything! Now we know where all the extra water was going. I gather an ice dam formed somewhere under the rocks, then broke. We won’t have that problem here; we’ve injected a lot of steam into the rock pile to heat it up.”

“And the slope is supposed to be covered by olives, right?”

“With a vineyard running up the middle. They want to export wine to the hotels in Earth orbit. The slope’s microclimate is supposed to be perfect for vineyards.” He pointed back at Caribbean. “These two enclosures share a common water supply because the Caribbean climate has dry winters and wet summers, while the Mediterranean climate has wet winters and dry summers. And the environmental management folks have really figured out the thermal regulation; I am constantly amazed. But let me show you Caspian Enclosure.”

Will nodded and followed Ramesh across Mediterranean, then southward along the eastern wall, which consisted of fake concrete rock punctuated by metal doors every ten meters. Ramesh pointed. “The housing modules behind each of these doors are already placed; we installed them when we excavated the area for the enclosure.”

“That simplifies installation of the pressure membrane between enclosures.”

“Exactly. We used eight by eight by twenty-five meter nickel-steel boxes made from Uzboi nickel-steel, four of them in a row, with two meters of reg between each row and three meters of reg and ice on top of each one for radiation shielding. They come with precut skylights. With three stories in each box, they can house and provide work space for 1,600 people.”

“That’s most of the next columbiad, for Aurorae.”

“The space between Mediterranean and Caribbean has just as much space. By mass producing the modules and emplacing them all at the same time, their cost is halved. We’ve already sold 95 of the 120 modules lining the two sides of Caribbean.”

“Can we go inside one? I haven’t taken an inspection tour. I’ve been leaving that to inspectors, increasingly.”

“Ah . . . sure.” Ramesh seemed upset the boss wanted to take a look. They walked to the nearest door, where Ramesh pulled out his communicator and punched in a code. They heard a clicking sound, then the heavy steel door slid to the side. They entered an airlock two meters wide and three long. An LED panel glowed dimly overhead. The far door slid open once the door behind them closed and they entered a big rectangular metal box. Considerable light streamed in through the strip of skylights along the middle of the ceiling.

Will tapped the metal wall. It echoed through the big space. He looked around; it was being used for storage, so it had a pile of boxes along one wall. He nodded. "I can see the three levels of apartments facing the central garden, the recessed patios on the second and third levels, the children playing, the adults walking around and talking . . . very nice."

"Most people prefer construction in the open, but these have more skylights than the older units, and they'll definitely be cheaper. You probably noticed that the doors to Mediterranean are bunched in pairs. Two pairs of doors will open onto an 'alcove' or minicourt thirty meters wide, which will be partially enclosed by residential and commercial buildings. A street will run along both sides of Mediterranean; people can take them to the Agora for shopping or public transportation to the rest of Aurorae. Two thirds of Mediterranean will be agricultural."

"I'm amazed by what we've been able to do. Mediterranean will recycle all the wastes and provide all the oxygen for the people living along and in it."

"Well, wait till you see Caspian." Ramesh pointed back to the door and they stepped into the airlock, then back into Mediterranean. They walked southward to the base of Layercake Mesa, then began to climb the slope along the west edge; fortunately the plastic-enclosed dust cloud was on the east side of the slope, though the air did have some dust in it, in spite of fountains of water being sprayed on the dirt.

They walked half way up the slope until they could easily see over the five meter concrete edge of the enclosure. Caspian was a hundred meters to the west. Two huge regolith sorters were hard at work on the future polder itself, digging up the ground to the depth of three meters, magnetically removing all nickel-iron fragments, crushing rocks

that could crush, piling the rest in a trailer for disposal, then feeding the excavated materials back into the hole, small rocks on the bottom, then gravel, then pebbles, then the finest stuff on top. Computer-controlled pile drivers were already at work, installing lines of pilings, some angled inward, others outward, like giant tent stakes. At the far side of the work area, bulldozers were digging a trench ten meters deep where a metal and concrete wall would be built; an airtight metal curtain would be driven five meters farther down to provide an airtight barrier fifteen meters below the surface, against which they'd maintain a water table to prevent the downward escape of air. Bulldozers were also busily excavating the ground beyond the far wall of Caspian so that metal housing boxes could be emplaced and buried.

“How wide?” asked Will, squinting at the distance.

“Seven hundred meters, with two lines of pylons running down the middle to hold down the dome, which will soar to 350 meters. Caspian will be a kilometer long, so its area will be 700,000 square meters, enough to provide for 5,000 people. It'll be finished in time for the twenty-first columbiad in 2076 and should provide for that entire wave.”

“The statistics are mind boggling,” replied Will. “About a million tonnes of water underneath and thirty thousand tonnes of air overhead, several million tonnes of ground to heat up . . .”

“But very doable,” replied Ramesh quickly. “We have all the water, air, and heat we need. These are the sorts of enclosures we need to build for the immigration waves we anticipate. If we're bringing in 40,000 immigrants, a decade from now, that columbiad we'll need six million square meters of new polder, four million square meters of new housing and work space, six million tonnes of water, a half million tonnes of oxygen and

other gasses, 400,000 kilowatts of power . . . it's staggering, but we'd have perhaps 150,000 people to provide them."

"And beyond Caspian . . . Atlantic?"

Ramesh nodded. We're designing it now. It'll have three rows of pylons down the middle and be 1,000 meters wide and 500 meters high. I'd make it at least a kilometer long, but we're looking at 1,200 meters and 1,500 meters, depending on how big the immigration wave proves to be. Caspian is the last enclosure that abuts Layercake Mesa, which ends two hundred meters farther to the west. So Atlantic enclosure will be shifted a bit to the north. If it's a square kilometer, its agriculture can provide for 6,000 people. Then two years later we'll have Pacific ready. We're looking at four rows of pylons down the middle, a width of at least 1,250 meters and a length of at least 1,500 meters."

"Able to feed eight to ten thousand." Will contemplated. "And are you sure that something as wide as Pacific is better than two Mediterraneans? Because we're putting a lot of eggs in one basket. One design flaw and we'll have a severe crisis, possibly multiple deaths."

"These are all oversized by a factor of three; they could hold in a terrestrial atmosphere of pressure if necessary."

"But metal and plastic fatigue over time. How much will they be oversized in 20 years? Thirty?"

"These are essentially the equivalent of suspension bridges, except the pull is upward instead of downward. The Brooklyn Bridge is a century and a half old. They certainly will require maintenance. We may want to drive additional piles, add additional cables, even add an extra layer of plastic over the top, just as we did over Yalta, Catalina,

Riviera, and Shikoku. We've left places where additional pylons can be driven outside. It will be possible for workers to work on the outside as well."

"Good." Will nodded, but he still didn't seem satisfied. "Construction soon starts on Uzboi 5, which will increase the area of polder there by 200%. Cassini 6 will increase Cassini's polder area by 300%. Dawson 2 will do the same at Dawes. The new enclosure for Tithonium will increase its area 500%. We used to build enclosures that added no more than 30% to any outpost's area. These are enormous increases, all dependent on the same innovative design."

"But it's a very good design!" exclaimed Ramesh, defensively.

"I'm sure it is, Ramesh; you are an absolute engineering genius. I don't know what we'd do without you. We now have an incredible engineering design team, a fabulously efficient and reliable materials fabrication company, construction specialists of the highest professionalism anywhere, a very capable urban design team, amazing environmental management capacities . . . but we also have greater complexity than ever, and greater potential for disaster than ever. So I want an outside engineering audit of the design and an audit of the construction procedures."

Ramesh was shocked. "How can we do that? It's not like we have outside experts a one hour flight away!"

"I know, but there are still some berths on the December flight. We can probably hire some experts to fly here; they'd arrive with the tourists, they'd have a month to inspect, and they'd fly back with the tourists via Mercury. Or we can look at the arrivals and see if there are engineers among them with the requisite experience. A lot of the auditing can be done on earth using the construction records, which are very thorough."

“Will, this is a huge request. It will cost millions and could delay everything for months. It’s really not reasonable!”

“I’m sorry, Ramesh, but if the slightest design flaw is overlooked, if a single procedure welding or emplacing cables has potential problems, if a single manufacturing process produces flawed materials, we could get a dome failure. If it happens at Tithonium, they’d lose five sixths of their pressured space. If it happened here, we suddenly wouldn’t be able to raise food for several thousand people. Those are not trivial concerns. We must be vigilant at all times.”

“Will, have you any idea how thorough the design processes are? How many people checked them for us? There have indeed been audits, all along as we implemented the designs. The construction procedures have been checked and rechecked. The materials manufacturing processes are of high quality and extremely exact. The real overdesign margin may be four fold, rather than three!”

“Perhaps it is, but let’s check one more time. I’m going to ask Rachel Evans to organize an audit. She was head of safety some years back, but then left and served as Mayor of Uzboi until recently. Like I said, I have complete confidence in your capabilities, but no one is perfect. That’s why we have audits. We owe it to the people who risk their lives to come here.”

“Please, I beg you to reconsider this.”

Will shook his head. “Let’s make sure these designs can keep expanding, so we can build domes two, five, even ten kilometers across. We may not need to terraform this planet if we cover its surface with reliable enclosures! Let’s spend the money and check everything.”

“Alright, have it your way,” replied Ramesh, his face tight with emotion. Will looked at him, wondering whether he felt his professionalism had been insulted, whether he was hiding something, or whether he felt bothered. But it didn’t matter; there was going to be an audit.

Helmut had never been on a galleon before. Making a three dimensional virtual reality tour of the *Sagittarius*, he regretted in a small way that Ceres had been settled when it had, before galleons had been launched. It had 22,000 cubic meters of interior rather than the caravel’s 7,700; three times as much. With agriculture moved out, into enclosures on the surface of Ceres, a galleon could accommodate 150 people; currently they had just 71. Mars had just confirmed that it would launch the galleon *Herschel* to Ceres during the next launch opportunity from the Red Planet, which was the summer of 2077. Helmut dearly hoped he could convince them to speed up the timetable by launching a galleon to the Earth first and sending it to Ceres from there. But he was pessimistic. When the *Bode* arrived in 2074, Ceres would have three caravels and about 150 people.

Meanwhile, a message had arrived from Carter Levine. The engineer, who had made a definite commitment to come to Ceres—in spite of the concerns of half the population of Uzboi, including Mayor Moreno—was emailing a new idea almost every sol. He hit play.

“Good sol, Helmut. I was videomailing some of my colleagues at Parenago yestersol. As you may have heard, they just announced a plan to double their PGM production to a thousand tonnes per year, one third of terrestrial demand. One just sent me a new report of the Lunar Commission that explains how they plan to do it. As you

may know, the Prometheus stages have been designed with four fuel tanks rather than two, which allows them to be fueled by methane or hydrogen. The engine family can handle both, though individual engines need to be swapped out of course. A Prometheus first stage fueled with hydrogen and oxygen, launched from Peary, can send 600 tonnes from the lunar surface to Earth for R6.50 per kilogram. If the cargo is formed into hollow spheres with a heavy side that is covered with a spray-on ablative heat shield, the sphere will hit the atmosphere, automatically orient its heat shield downward, and slow to a terminal velocity of several hundred kilometers per hour; sufficiently slow for transport of PGMs. That's how we get Mars's PGMs and gold to Earth; they're placed inside spherical nickel or cobalt capsules, a group of capsules are launched to Earth together on a solar sailer, it releases them after a lunar gravity assist, and they crash land and are recovered.

“But the important point for Parenago is that nickel currently sells on Earth for 8 redbacks per kilo, and cobalt sells for 12 redbacks per kilo. Therefore, the Prometheus stage will make it possible to export nickel and cobalt to Earth profitably, as well as PGMs. The profit will be much smaller, but the quantity is vastly larger; every tonne of PGMs requires the processing of three to ten thousand tonnes of nickel-iron, producing thousands of tonnes of nickel and dozens to hundreds of tonnes of cobalt. Terrestrial demand for nickel and cobalt are correspondingly larger, too—two or three million tonnes per year for nickel and over one hundred thousand tonnes per year for cobalt.

“Here's where Ceres comes in. The lunar surface to earth requires a delta-v of 2.3 kilometers per second. Ceres to Earth requires 4.8, but with a Martian gravity assist it's 2.7; nearly the same as the moon! A Prometheus first stage should be able to push close

to 700 tonnes of cargo from Ceres to the Earth via Mars, so the costs should be the same or lower than from the moon. Ceres certainly could export cobalt. If the Prometheus gets used this way, it will make many, many more flights and it will be improved, which will lower its costs still further. At that point, even Mercury might be able to export cobalt to Earth via a Venus gravity assist; the delta-v would be 6.3 kilometers per second at aphelion.

“The Lunar Commission will almost certainly purchase a Prometheus first stage, so I suggest the Asteroid Belt Commission consider doing the same. It appears to have a lot of potential. Let me know if I can provide any additional information. Bye.”

“Wow!” Helmut said to himself. PGMs were currently fetching 15 million redbacks per tonne. But if the production of each tonne of PGMs also produced ten tonnes of cobalt, that was 120,000 redbacks more; and if each produced a thousand tonnes of nickel, that was 6.5 million redbacks more. It wasn’t a lot more money, but it increased their income thirty percent, and that was worth considering. Their goal was 100 tonnes of PGMs and 1.5 billion redbacks per year, enough to pay for the expansion of Ceres and fund at least two caravels exploring the Belt. Based on Carter’s suggestion, that would require 150 Prometheus launches per year, almost all of which would push nickel exports to a Martian gravity assist. Helmut doubted the Prometheus was necessary; the escape velocity of Ceres was just half a kilometer per second, so very small, cheap, locally produced rocket engines would work fine. Either way, the launches would require an enormous expansion of their propellant production, probably costing a billion redbacks. On the other hand, it would make the refueling of visiting caravels a trivial matter. Working a propellant production facility that much would make it very cost

efficient. Making spherical capsules of nickel with their own cheap engines, running such a big refueling facility, and launching them at such a rapid clip would employ many, many additional personnel. Undoubtedly, Ceres would have to expand. That would reduce their personnel costs further, because larger settlements had lower environmental management costs per person, had a wider range of services, and better quality of life.

It was exciting!

He hit reply. “Thanks, Carter; you’re always on top of the latest plans! Can you get me a detailed report, or perhaps a copy of the Lunar Commission’s report? I figure it’ll increase our income only about thirty percent, but it’ll force significant expansion of our facilities and staff on Ceres. This is principally a borough matter because Mars is paying for Ceres infrastructure, so I need to contact Jacquie Collins about it. But I will seek more information through our staff on Earth. Bye.”

Helmut turned to his inbox; sure enough there was a message from Quentin Pauwels reporting on his visit to Lagos and his trip fifteen kilometers from his home in Waterloo to the office of Belgium’s Minister for Space Exploration. Both visits had gone very well.

“Thanks, Quentin. I’m glad the Nigerians have agreed to an expansion of their mission to include Eunomia; that’s four targets and quite a tour of the Belt. And who in a million years would have thought the Belgians would consider a national mission to Hygeia! That’s fantastic! Let’s pin down the date.

“But I wanted you to make a different sort of query for the ABC: the purchase of a Prometheus first stage. I have just heard that the Lunar Commission is considering export of cobalt and even nickel from the moon to Earth because the launch costs of a

Prometheus are so low. Using a gravity assist at Mars, our launch costs may be even lower, so we could grow quite a lot and increase our income. We may not need a Prometheus, and I suspect there's quite a backlog for purchasing one, but could you ask? Thanks. Bye."

"Come on, Rajiv," said Ramesh to his 9 year old son.

"Dad, I don't want to go with you, I want to stay with mom!"

"Rajiv, I have custody this weekend, so come on!" Ramesh grabbed the boy's arm and pulled. Rajiv came along reluctantly; twins Hridaynath and Jayanti, both 7, followed meekly.

"I'll pick them up at Cochabamba transit center Sunday morning before mass," said Sarah, watching her children go.

"Okay," said Ramesh, adding a grumble, "mass."

Crystal reached out and took Jayanti's hand, but Hridaynath rejected it; he didn't like his step mom and made it clear to her on almost every occasion. They descended from the Gallerie's main level to the public transportation tunnel where a robotic taxi—just a big golf cart—pulled up for them. They got in and headed for Cochabamba.

No one spoke; the kids were sullen. At Cochabamba they transferred to the 7 p.m. robotic bus that would head to Canyons Meadows and beyond to New Tokyo and the Dacha. A few others got on as well; the bus waited until 7:02 for someone known to be in a robotic taxi on the way. When she got on, the doors closed, the bus drove into the airlock, and it headed along the metal highway toward the escarpment. In twenty minutes it pulled into Canyon Meadows' transit area and they stepped out. Ramesh had finally

managed to sell the dozen other lots, so the “meadow,” which was pretty in grass, shrubs, and flower beds, had six houses on each side and one on the far end. The three kids tore across the meadow shouting and leaping while Ramesh and Crystal carried their backpacks to the door of the house, then shouted at the kids to come inside in the fading twilight of a Martian sunset.

Inside, Crystal turned on the television so they could all watch a favorite show. They settled in and Ramesh tried to pay attention, but finally pulled out his tablet to read email. “You never pay attention to us,” admonished Rajiv, and Ramesh scowled in return, but returned to his work. It never ended; he preferred it that way.

The tablet jangled, startling him; a videophone call was coming in. He looked at the caller id; it was Tree Rivers. He rose and walked to his office, where he could sit and take it. “Rivers, it’s after hours here,” he admonished.

“Since when do you follow work hours? I had an inspiration to call.”

“Prophetic, or some other kind?”

Tree was taken aback by that comment. “ ‘Prophetic’ is such an imprecise word. Sometimes the Earth Mother inspires me; sometimes it’s Father Mars. The best inspirations come from both or are from one and endorsed by the other. They’ve been whispering to me a lot, lately, about Themis.”

“What?”

“Themis, the daughter of Gaia, the embodiment of divine order. It orbits the sun, perihelion inside the earth’s orbit, aphelion almost to Mars’s orbit, inclination to the ecliptic ten degrees—that’s why it never collides with Earth—and its year lasts about 448 Earth days.”

“An . . . asteroid?”

“Indeed. Surprisingly round; it has nickel-iron and carbonaceous chondrite or cometary debris. It’s about three hundred meters in diameter. We need a dome 500 meters in diameter to wrap around it.”

“Are you crazy?”

“I most certainly am not! Father Mars has been pushing this on me insistently since the war ended. We talked about the project last year and since then the Venus Commission has approved a project to put a series of small bodies into Venus orbit—”

“But not a dome! They want a fifty-meter nickel-iron body by 2077 in a 24-hour elliptical orbit around Venus and then three carbonaceous chondrite bodies of similar size to put around it, with a galleon underneath the chondrite shielded from cosmic rays.”

“Have you seen the report about a domed asteroid they commissioned?”

“Yes, I skimmed it; a recommendation they rejected, remember, because of micrometeoroid and cooling issues.”

“No, those are not the reasons they rejected the design. They solved both problems with a system of ‘venetian blinds’ attached to the outer dome that could admit sunlight at certain angles, and at other angles they could produce solar power on one side and radiate waste heat on the other side, plus provide fairly effective micrometeoroid protection. The problem was cost; they were looking at manufacture of the systems on the Earth’s surface and launching them into space with the Swift shuttle. But manufacture of the essential systems on Mars and launching them with the Prometheus—or even better, manufacturing them on Phobos—changes the entire picture.”

Ramesh sat up in his chair. “I suppose it does. But their estimate was twenty billion redbacks, if I remember my conversion from geos correctly.”

“My calculation was twenty-one billion. But we can use standard solar panels on Themis’s surface for power at first and once we go into PGM production, we can manufacture the venetian blinds on site from spare iron. Pumping the heat upward to the third and outer dome would radiate away a lot of it; the rest can go into heating the asteroid itself, which will take several years, at which point the venetian blinds will do the rest. So all I want from you is an estimate for the mass and cost of a triple dome 500 meters in diameter. The outer one should be designed to hold in $\frac{1}{3}$ of an atmosphere and will normally have less than $\frac{1}{10}$ atmosphere pushing against it. The second dome will have $\frac{1}{5}$ atmosphere and should be triple redundant. The inner dome will have a third of an atmospheric pressure underneath and needs to be triply redundant. The domes would be 1.5 meters apart and attached to towers at the asteroid’s north and south poles. We’d build the outer one first, start manufacturing air from the carbonaceous material to inflate it, then manufacture the middle dome, then the inner dome last. I’ll send you the specifications.”

“What will you do with a micrometeoroid impact?”

“Patch the pinhole. We’ll have several per year. Themis has PGMs we can mine to pay for the work. Its surface area is roughly 250,000 square meters; enough to feed at least a thousand people, more with underground greenhouses. It’ll be a beautiful place, clothed with life, the first of many worlds we’ll turn green.”

“Well, get us the specifications and we’ll see what we can do with them,” replied Ramesh, irritated by the prophet’s effusiveness. “Did you talk to the Venus Commission?”

“Yes, and they rebuffed us. They can do their project their way and we’ll do ours our way. I think our way will be much more pleasant, too. My sources say they’ll come around.”

Ramesh wondered whether he was referring to the Earth mother or contacts inside the Commission. “Like I said, send your specifications. I’ve got to get back to my family. Bye.” Ramesh hung up before Rivers could offer a goodbye as well. The “prophet” irritated him. But the Venus Commission’s report had also irritated him, though he had spent only five minutes looking at it. He pulled it up on the electronic paper on his desk and started to skim it. It offered various options, including an entire purpose-built rotating cylinder five hundred meters long and a hundred meters in diameter with the housing and gardens built against the inner surface. They had gone with the cheapest option; a galleon landed on a nickel-iron rock “core” that provided metal for construction and a modest amount of PGMs for export with stony or chondritic material serving as a “mantle” around it, providing radiation shielding and a source of volatiles. The artificial moon could start very small and be augmented over time as the station’s needs grew. It was a clever arrangement.

Ramesh skimmed the section that proposed a dome over an existing rock. While he didn’t find the idea as elegant as the plan the Venus Commission had approved, it had a simplicity and a familiarity—living on the outside a world—that felt comfortable. No doubt the cabin-fevered astronauts in Venus orbit would agree. It had an attractiveness as

well. But the engineering irritated him. “Not very clever passive cooling,” he complained to himself. Mars had mastered the problem of cooling their enclosures, which a steady stream of sunlight would overheat otherwise.

“Dad, are you coming?” called Rajiv.

“I’ll be right there!” He was surprised to see fifteen minutes had passed since he had hung up on Rivers. He looked further. The dome materials were not as well chosen as they could be; Mars had mastered a mix of plastics and metal cables that complemented each other in terms of strength, thermal conditions, radiation, electrical grounding, light transmission, and overall aesthetics. And the cost estimates! Phobos could do most of the work, and much more cheaply. The engineering research would be immensely supportive of their existing capabilities and would help them develop new capacities.

He nodded and closed the connections; the electronic pages went blank. This was an important project for Mars to tackle.

The caravel *Victoria* flew from Elivagar Flumina to Acheron in just two hours. The spacecraft rose out of most of the atmosphere—it was hard to get out of all of Titan’s fluffy ball of nitrogen and methane—then fell back in, glided to its destination, and fired its engines briefly to remove the last hundred kilometers per hour of velocity. In half an hour a heated and oxygenated tunnel had been attached to the basal airlock of the vehicle and they all began to file out.

“I wish you’d reconsider joining my three-moon expedition, Marshall,” said Johnny. “There’s still room. We blast off February 1; just ten days away.”

“Thanks, Johnny, I appreciate the offer. And I’d love to see Mimas, Tethys, and Dione. But six months is just too long to be away. Willie’s just a little over three years old and Amy’s pretty busy with environmental management. I need to be around.”

“I suspect starting next year, the expeditions will be shorter; one to three months. I’ll be gone and whoever plans them will probably favor one-moon visits.”

“Well, you’ll have landed on all the important ones, so all that’ll be left is exploring them in detail. That’s best done with a mission of a month or two that has specific objectives. Then we’ll return here, write it up, publish it, and plan the next set of mission objectives.”

“The moons will gradually get bases, too,” said Johnny. “Anyway, keep it in mind. We’ll be back here about August 1, six weeks or so before the *Cassini* arrives. I’m sorry to be leaving, but Tad needs to go back to Mars.”

“What will you do there?”

“I don’t know. I can’t run for office! I’ll ask the Chief Minister—maybe it’ll be your dad—for a good assignment, or maybe the ABC can give me an asteroid expedition. Or maybe after a few years and Tad’s settled, I’ll go to Callisto. I’m 56; I’ve got at least ten good years left.”

“Mercury would be a possibility, too, and quite a contrast.”

“Nah, I’ve gotten used to cold places!” Johnny chuckled.

The elevator had brought them down to the surface of Titan, so they stepped out of the elevator and into the thick plastic tunnel that led them down into Acheron. Amy was busy working on the crops in N-2 that day and Willie was in day care, so he headed home with his bag. Most of the contents went straight into the laundry hamper, which

was full, so he picked it up to carry it to laundry area. No sooner had he dumped the load into the receiver—it would sort by color, spot stains, wash, press, and fold in two hours time—than his communicator rang. It was Amy.

“Hi love,” he said.

“Hi; have you landed already? I’m sorry, I’ve lost track.”

“Yes, less than an hour ago. I just dumped all our laundry into the washing system and was coming to the main cafeteria for lunch.”

“Good, I’ll join you there. I have exciting news!”

“Oh; what?”

“I’ll tell you when I get there. Bye.”

“Okay, bye.” He closed the circuit and headed for the cafeteria in the underground complex. He wondered whether she could possibly be pregnant. They had been talking about having another child, but were still waiting and using birth control. He quickened his step to the elevator, up to the *von Braun*’s central hub, down to the surface of Titan, then along a tunnel several hundred meters to the cafeteria.

She was waiting; she had to come just two bubbles. They kissed. “How are you?” he asked.

“I missed you!”

“I’m glad to be back; I missed you, too. What’s the news? You aren’t pregnant, are you?”

“No! Soo is, though. That’s why she skipped the trip to Elivagar. We’re having a second baby boom.”

“Makes sense; we’ve settled in, we’ve been here two years, and we can all take a vacation once the *Cassini*’s personnel arrive. Here, let’s sit. So, what is it?”

They sat at a nearby table by themselves. “Environmental management just had a big meeting today; all thirty of us, horticulture, waste management, water recirculation, atmospheric management, everyone. The agenda was planning the next three or four years. We know what’s coming on the *Cassini*, but attitudes have changed a lot in the last six months in that Acheron is established, it’s permanent, and it’s our home for a lengthy period of time, so we need to make it stable, safe, and comfortable. The discussion boiled down to one question; how big can we make this place? Because the bigger it is, the more caverns it has, the safer it is, the more pleasant it is, and the more diverse the ecology can be. Mars learned the importance of ecological diversity during the war when they couldn’t import a lot of items; the ability to produce a variety of chemicals, substances, and objects from different plant species became quite apparent. As a result, they increased the recommended number of square meters of plantings per person from one hundred to one fifty.”

“A huge commitment, in terms of construction, though the new techniques have helped. But we can’t do that here.”

“Why not? We voted to increase our plantings from seventy-five square meters per person to two hundred over the next five years!”

“But how would we light that much space? You’re talking about going from forty kilowatts of lighting per person to about one hundred ten. If we have 500 people, that’s fifty-five thousand kilowatts. We can only make forty-five thousand now and half of that is reserved for manufacturing.”

“The power line to Likoma should be finished next year and the *Cassini*’s bringing steam and wind turbines. They should be able to double our power supply. More important to how much planting space, however, is how we use it. We’re getting four hundred more species, most in seed form, and we have no plan yet how we will use them; seeds are so easy to import, we imported just about anything we could think of! Basically, we plan to set up a series of bioarchive parks, eight of them initially, each 5,000 square meters. We’re counting on construction to build metal Quonset huts, basically, one hundred meters long, fifty wide, and up to fifty meters high, in which we can place a meter or two of soil, grow lights, and a watering system. Each will be a distinctive climate: tropical, semitropical, arid, savanna, Mediterranean, Sahel, temperate, and arctic. The floors won’t be flat; they’ll be sloped so that the spaces have springs and possibly small brooks. If we can manage it we’ll create a salt water and a fresh water biome as well.”

“That will be fantastic! Acheron will be huge, with something like that!”

“Exactly, and it’ll have immense ecological diversity. No Titanquake or explosion could ever wipe it out. As long as we’re here, we’ll maintain a huge bubble of Earth. That means, in a decade or so, we’ll have tropical fruits, hardwoods, natural rubber, and all sorts of medicinal plants. We’ll harvest resources from them. If we can import animal species, we will; not lions and bears like Mars, but maybe deer or raccoons or antelope.” She smiled. “And I’ll be in charge.”

“Really? Incredible!” He leaned over and kissed her.

“Yes, they confirmed it this morning. It’ll be my job to set up the teams in charge of each biome and sit in on their meetings to plan each one. We’ll be lucky to initiate two

per year; it'll be a long process. It'll require more personnel, too, because each half-hectare of space will require at least one full-time position to maintain."

"And you only have ten horticultural specialists right now."

"Yes. If we want Acheron to become a stable, comfortable settlement, we'll need at least dozen more horticulturalists. Eight more are coming on the *Cassini*."

"The percentage of explorers will decrease, but we'll be able to do better work because people will want to stay." Marshall smiled. "What an exciting development for you! I'm really thrilled!"

"It sounds like we're not leaving for a while."

"Well, I didn't want to leave for a while. Considering the fertility problems people are having up here, and the genetic defects that have popped up, I'm not convinced it's healthy to haul kids through interplanetary space. Willie shouldn't leave for another fifteen years."

"And if we have another kid, it'll be at least nineteen."

"Yep. I'll be 53, then, and you'll be 52."

"A long time, to learn to love this place."

"Well, it's a hard place to love! Besides, you need time to grow some forests. Ecologies are not easy to establish and bring to maturity."

"They take as long as children!"

"I suppose you asked to meet with me about the temple," said Lal Shankaraman as he sipped his coffee with steamed milk. He looked across Punjab Square at the temple. "I am

always surprised you are so devout in supporting it. I suppose you don't believe in the gods."

"Auspicious Shiva, lucky Ganesh, and Kartikeya, the god of war and of Mars?" asked Ramesh, from their table at the café. He could see elephant-headed Ganesh looking back at him from across the square. "I suppose I believe in some sort of divine force. Certainly I believe in a divine force within all of us, and Siddharth has taught me to access it within me." He was referring to the temple's lone priest. "So I suppose I believe we are the true incarnation of the gods. You want to meet someone who really believes Mars is a god?"

Lal raised his eyebrows. "Really? Who?"

"The so-called prophet, Tree Rivers. He speaks of Mother Earth and Father Mars all the time, as a divine pair and the source of his 'inspiration.'"

"Really? Perhaps I should tell him about his god's glaciations and interglacials, then!"

Ramesh laughed at that. "No, that's not why I called you. I wanted to ask you about—" And just then his communicator vibrated in his pocket. He frowned and pulled it out. The text message said, *Yes we will pay ₹200,000 for a study. Thank you, we have every confidence in you. Tree.*

"Good."

Lal had seen the message. "The prophet himself?"

Ramesh nodded. "He wants a study of how to terraform a small asteroid with a bubble. It would seem the Green World community wants to green as many worlds as possible; they're not stopping with Aram crater. He had looked at the Venus

Commission's study and had thought of some modifications. My team and I spent an afternoon doing a seminar about the study and ripped it to shreds. We think we can prepare a much better proposal."

"But there are so many problems; micrometeoroids, heat rejection, radiation . . ."

Ramesh shook his head. "Piece of cake. In microgravity you can suspend a lake overhead. Imagine a one-meter thick layer of water, then a meter-thick layer of ozone gas to block ultraviolet, then another meter thick layer of water. Two meters of sterile water will stop all solar radiation and a lot of cosmic radiation, but will let through the sunlight. Micrometeoroid pinpricks will be easy to find and patch. And once the asteroid body heats up, you expel extra heat into the outer layer of water so it can radiate into space, and you use a heat pump to keep the lower layer cool, so your atmosphere has normal vertical circulation. It takes a lot of electricity, but there's plenty of sunlight in interplanetary space." Ramesh smiled at his solution.

"That is clever. Is microgravity enough for convection, though?"

"Very slow convection, yes, aided by fans." Ramesh sipped his coffee. "But that's not why I asked to talk to you. Do you think Elliott will run for a third term?"

Lal scowled. "We don't 'run' for offices up here, remember, Ramesh?"

"Alright, let me rephrase; will he accept a third term?"

"No one knows, and he hasn't even hinted. He said once he thought two terms were enough, though."

"And this is the second term."

"It is. So?"

“Because I want you to be the next Chief Minister! You’re speaker of the Mars Council; you’re number two! You’re the logical choice.”

“Then let’s leave the matter and see what happens.”

“No, Lal, you at least need to be more active. When Jacquie Collins was Clerk, she was far more active in the Council than you, talking to people, bringing them together, discussing legislation with them, organizing task forces.”

“Yes, I know. But I’m primarily a glaciologist, remember? I’m pretty good at managing discussion; I’ve been chair of the geology department forever for that reason. But my main interest has been Martian glaciology. We’ve now reconstructed the advance of ice sheets during several of the most intense Noachian hibernals, and some of them correspond with the earliest known Archaean glaciations on Earth. The synchronicity has helped us reconstruct the history of the eccentricity of the Earth’s orbit as well as Mars’s, and with radiogenic techniques we seem to be on the verge of reconstructing the history of the variability of the sun’s output. That’s valuable and important research with implications for the Earth’s future. That’s been my focus for over a decade. The speakership is important service to Mars, but it isn’t my highest priority.”

“But what about being Chief Minister?”

Lal hesitated. “Well, that would be a nice challenge to face.”

“That’s right! And an Indian should have the challenge, so you’re the man. You need to think about efforts you can make to put yourself in a more prominent position. Issues statements about things, make comments in press conferences, propose legislation at the upcoming session. The budget for the next fiscal annum is a big opportunity to make a mark, don’t you think?”

“Yes, I do, but I don’t have a particular vision that provides a stamp to the budget.”

“Then develop one! I can help; I have ideas.”

“I’d like to hear them, sure.”

“Good. That’s half the effort. The other half is lining up support.”

Lal shook his head. “No, that’s electioneering. Let’s not forget what happened to Bruce Cowdrey when it came out that he had cut some deals.”

“Nothing will come out; we have to be very careful. You only need to influence three or four votes, I think. In the first ballot, the votes are always split among a lot of choices, but anyone with a slight early lead can see it snowball.”

“That’s true.” He considered. “I won’t have anything to do with it, though.”

“That’s fine. You put yourself forward and I’ll do some talking to people.”

17.

PGM Rush

March 2073

Charles Langlais pulled up the next infrared image of a section of Lutetia on the big screen in front of him. It was shot in a particular infrared wavelength that produced a false color blue and red image of the area, for absorption at that wavelength was characteristic of the asteroid's nickel-iron bedrock, so it showed in blue, while the loose regolith, dominated by chondritic and carbonaceous asteroidal debris, was reddish. He carefully overlaid the image on part of the geological map he and Firuz Moulin were making of the Baetica South Quadrangle. The image overlapped with another image and he checked the red splotches on the new image with bedrock units he had identified on the other one. He had missed a few on the other image because of foreshortening, so he added them, then saved the result. The rectified image was added to the map's data dossier.

Firuz, who was working at the next work station, leaned over his shoulder. "Looks good. I've just finished checking all the laser altimetry data and compiling it into a contour map. Let's superimpose it."

"Okay." Charles saved his version of the map and leaned over Firuz's shoulder while the older man combined the two maps together, then saved it as a new master map. In seconds the quadrangle map popped up on his computer screen with a series of colors ranging from green to brown to white indicating increasing altitude.

"Wow," said Charles.

“Cool isn’t it? Can you imagine having to do all this by hand, a century ago?”

“No. But even computer-aided cartography takes skill.”

“Definitely, and talent. And you’ve got it.”

“Thanks, Firuz.” Charles glanced at the chronometer on the bottom of Firuz’s screen. It was 12:15. He turned back to his screen and clicked on the “window” icon. The map disappeared and in a second was replaced by blackness, broken by a single bright spot near the middle.

“I think I can still see the disc.”

“Barely. In a day and a half we’ve come about a half million kilometers. By tomorrow, Lutetia will be a point of light.”

“Do you think it’ll ever be visited again? Or settled?”

“Visited: definitely, maybe in a decade. The geology’s that good; where else can you see the naked metal core of an asteroid? Settled: probably, some day, but who knows when. Because the PGM rush is now on. Earth’s demand for them is 3,000 tonnes per year. Parenago and Uzboi both plan to expand to 1,000 tonnes per year. But as they expand, price won’t fall much, because terrestrial operations losing money will be forced to close, decreasing the supply. Prometheus and industrialization in low Earth orbit have pushed down launch costs so much, PGM recovery is much cheaper in space than on Earth.” He sighed. “And Mars wins big as a result. Parenago needs Mars-made reactors fueled by Martian uranium. Any PGM recovery on an asteroid or Mercury will use Mars-made solar panels. Just about everyone will be buying Marsian-made deep space vehicles, furniture, even consumables, thanks to Mars’s new capacities developed during or after the war. A colony on Lutetia could export PGMs forever; the place has literally

billions of tonnes. The trick would be competing against the more efficient systems elsewhere.”

“It sounds like the moon will be the big competitor.”

“Yes; they have the advantage of closeness. But they have shortages of carbon and power, which drive up their costs, and PGM demand is tied to the business cycle. Mars has plenty of power and carbon and has gold production, which is counter-cyclical; an economic downturn causes uncertainty and gold prices go up.” Firuz looked at the tiny blotch on the screen. “You were really taken by Lutetia.”

“It’s a fascinating place.”

“Yes, it is, but remember it’s your first love, but not your last. Concentrate on your career and getting a good, well-rounded education. Your dad didn’t end up as ABC Commissioner because Ceres was his first love—it was Mars—or because he was just a great geologist. He’s articulate, he writes well, he communicates clearly, and above all he sees the big picture. Study some history and economics. And some psychology.”

“History? I hate history.”

“Then give it another chance. It’ll help you see the big picture. What we’re doing out here is more than science. Even calling it ‘exploration’ as a justification is inadequate unless you see where we’ve come from and where we are going.”

Charles frowned, uncertain of Firuz’s meaning, so he continued. “We’re here to discover humanity. That’s what we’re really exploring: the capacities of the human species. Mars is just the first new society we’ve created; we’ll create a lot more, and they’ll have a much bigger impact on humanity than a lot of PGMs and Hollywood movies set on Mars.” He pointed to the chronometer. “Time for lunch.”

“Yes, let’s go.” Charles enjoyed his daily lunches with Firuz, who was something of the *Wolf*’s resident philosopher.

Firuz shook his head. “I’m not eating lunch today, I’m fasting.”

Charles remembered he had heard a reference to the start of the Bahá’í fast on the BBC earlier. “Oh, are you a Bahá’í?”

“Yes, didn’t you know?”

“No.”

“Well, I don’t talk about it too much because everyone else on board has heard me mention it on and off for four years.”

“We have one Bahá’í on Ceres, too. She didn’t say much, either, because no one was asking.”

“Exactly. Neither group was all that religious.”

“Now, your last name is French, and your Peruvian, but Firuz is a Persian name, right?”

“Yes, very good! My dad’s male lineage hails from France, but his great grandfather ended up in Peru and married into a local family, so I have Inca blood as well. My father’s mother was half Syrian, her father being a Syrian merchant, and he was of Muslim background. My father, knowing his grandfather had been Muslim, was curious about the faith, studied it in his first year of university, and converted, much to his parents’ shock. He applied and won a scholarship to the University of Tehran in Iran. There he met my mother, who was a Bahá’í, and he became a Bahá’í instead. I was born in Iran and was raised in Peru and Slovenia, and went to university in Mexico and in the United States. My brother’s married to a Thai woman and they live in Morocco!”

Charles laughed. “We’re all world citizens up here—or maybe I should say cosmopolitans.”

“We’re mariners,” replied Firuz, with a shrug.

“And you’ve never married?”

Firuz shook his head. “Not yet, and I’m forty. Maybe some day.” He shrugged again.

“Well, maybe when we get to Mars, we can go looking for women together.”

Firuz chuckled at that. “Maybe.”

“SCN-75A and SCN-75B have both performed a nominal shut down,” reported the captain of the *Bode*. “Engine cool-down is continuing on schedule.”

Will smiled, pleased. “Perfect trans-Ceres injection.”

“They’re good, reliable engines,” agreed Jacquie Collins. “Central borough more than doubles in size, once they arrive in a year.”

“Including two brief stops on the way,” agreed Will. He peered at the image of the shrinking caravel. The camera angle highlighted the conical addition on top, which converted the flying saucer shaped vessel into a capsule. Attached to the bottom of the caravel was a 30-meter long “stalk” forked at the end with two solid-core nuclear engines. Surrounding the stalk were two clusters of hydrogen tanks. “So, how long before we can add an inflatable cone to interplanetary caravels?” he asked Alexandra, who had come specially to watch the launch in the control room.

“This design should work fine, but a few months more of interplanetary cruise experience will be definitive,” she replied. “Conicals will be a standard addition to the

corvet, which should increase their passenger capacity to Mars to about 2,000 people. We'll outfit one caravel and one galleon with conicals next columbiad and see how they work out. It doesn't increase capacity as much as you think because it has to include the zero-gee gymnasium that is already added to every galleon."

"The *Bode* could carry about 125 on an exploratory voyage," added Jacquie. "But it's carrying 100 tonnes of cargo to Ceres instead, which takes up a lot of space. Further, the conical was specially built out of four progressively smaller inflatables stacked on top of each other, so that when the *Bode* reaches Ceres they can be removed and buried to provide additional low-gravity space."

"Conicals will require additional development before they can be used in interplanetary exploration," said Alexandra. "Not all species of plants that a mission needs are adapted to zero-gee, so an exploratory vessel still needs to maintain a gravitied horticultural area."

"By the time we launch a Uranus mission, will that have changed?" asked Jacquie.

"Maybe," replied Alexandra.

"Can we have a conical ready by 2077 when we launch the galleon *Herschel* to Ceres?" asked Will.

"Certainly, it'll be an expansion of the one on the *Bode*."

"Excellent, because we should send it along as well. We need to grow Ceres; it has immense PGM potential."

"How much PGM production are we aiming for?" asked Jacquie.

“As much as we can! More than Parenago, more than anyone mining Near Earth Objects. It’s one of the economic keys to settlement of the solar system. The lower launch costs of the Prometheus appear to be triggering a PGM rush, in spite of all the uncertainties about the development of the terrestrial economy. If others capture the market, we’ll be in trouble.”

“Investors trust us, too, because we provided a stable economic environment on Mars in spite of the war,” agreed Jacquie. “That proved to be an impressive achievement.”

“Yes, everyone wants to invest on Mars right now,” said Will. “So we need to be wise, not overexpand or get greedy, and manage our growth prudently.”

“The Prometheus has been yet another proof that we know what we’re doing,” added Alexandra. “The second one is now flying and both are breaking in quite well. We’ll definitely be able to fly one here this fall; we’ll have a third one flying by then.”

“How many orders does the company have?” asked Will.

“Only one so far, from United Spacelines, but they tell me they’ve received a lot of inquiries. Parenago Metals is considering a contract for two, with each stage able to fly independently. Lunavol, the new company that has purchased most of the mining rights for volatiles at the lunar south pole, wants a first stage so they can launch lunar water to L1 and low earth orbit. Demand is rising fast in both places. If we’re not careful, they’ll be able to undercut Phobos and will capture most of the market in the next few years.”

“We have higher water production costs, but lower transport costs, so we’ll have to watch that market carefully,” said Will. “The price of water is falling so low, it won’t earn us much money, anyway.”

“So, people aren’t rushing to replace their Swifts and Boeings?” asked Jacquie.

Alexandra shook her head. “There isn’t enough demand to support the switchover yet. It is estimated that low Earth orbit industrialization needs 3,000 tonnes of launch capacity per year, plus about a hundred tourist launches. The moon needs a similar number of launches. Two Prometheuses would be sufficient to provide all of that; each can perform 100 launches per year with 150 passengers or 60 tonnes per launch. The two Prometheuses owned by Spacelift, Inc., the company we own a fifty-one percent interest of, are sufficient for all our passenger and cargo needs, plus the needs of Mercury, Venus, with fifty percent capacity left over to sell to LEO operations. It’ll be several years before demand for LEO grows enough to require more Prometheus shuttles.”

“Do we have a confirmation yet that Parenago wants to purchase two more galleons?” asked Will.

“It’s looking that way,” replied Alexandra. “Maybe 3; they can’t get their PGM exports up to 1,000 tonnes per year without a lot more gravitied housing. They may buy two reactors from us, too.”

“We need a lot more interplanetary cargo production, Will,” said Jacquie. “Phobos is building twenty-five more solar sailers, but they’re sufficient to transport only 500 tonnes to Earth every columbiad. One Prometheus shuttle here gives us the ability to launch 9,000 tonnes from the Martian surface straight to earth per year. We need a lot more solar sailers, or we need to get rid of them. There’s no reason for LEO to import 3,000 tonnes from the surface of the Earth when we can send most of the stuff they need more cheaply.”

“You name it and we can now make it, too,” said Alexandra. “We can make all the engines the Prometheus needs; we should be exporting them to Earth!”

“I agree, we need to look at that issue carefully,” Will agreed. “The days are gone when all we could sell was volatiles, plastic furniture, and grain. The war forced us to come up with manufacturing plans, and last columbiad we got the machines to make almost anything, but not enough people or robots to run them. Next year we’ll get another thousand manufacturing specialists. I’m sure plans to use them to make exports are already being considered. Jacquie, can you look into it?”

“I will.”

“The twentieth columbiad needs to focus on building up our research and development capacities, too,” said Will. “The various R and D positions we advertised got an average of 25 applications each! Huge numbers of the candidates were excellent, too. Young scientists and engineers want to come here.”

“Martech has all sorts of plans for expansion,” said Alexandra.

“We could have received a million applications, if we had tried,” agreed Jacquie. “The situation on Earth seems hopeless to so many young people. Unemployment remains stubbornly high. Universities and other research facilities are starved for funding.”

“Then let’s start to reexamine Martech’s expansion ideas and formulate a comprehensive plan for the next columbiad,” exclaimed Will. “If we can export technology to Earth, that’ll guarantee our future better than anything else. PGMs are not guaranteed; it may prove cheaper to mine Near Earth Objects eventually, and that’ll undercut Uzboi and other Martian surface operations. The rich gold deposits will last

only another twenty years; at that point we'll be mining deposits no better than the ones on Earth, and will have high transport costs as well. But if we are producing ten percent of humanity's patents, we'll always have an export."

It was a gray day. Roger Anderson never liked dust storm season, especially when the dust was the thickest. He looked up; the dome over Andalus was covered by a film of powder, even though the automated air jets blasted it off every hour. It was a good day to stay inside.

He stepped into the Gallerie to get a coffee and a breakfast pastry, and he hoped he run into friends to talk to as well. As he stepped out of the Deseret Café, he saw his old friend Érico Lopes sitting nearby, talking to his daughter, Corrie. He waved to them, so Corrie stood up. "I'm leaving anyway, Uncle Roge."

"Really? I don't want to interrupt."

"No, she's on her way to work," replied Érico. "Sit down and join me."

"Alright." Roger and Érico sat together several times a week to debate the news, as they had been for thirty years.

"How's Madhu?" asked Érico.

"Already off to Catalina Biome to supervise work on the botanical garden."

"That's really coming along beautifully."

"Isn't it? It's an impressive space. She's been asked to develop gardens in Baltic next."

“Really? Fantastic. We have so many artists up here now, and that would have been impossible without Madhu.” Érico changed the subject. “So what do you think of the bombing in New York?”

Roger shrugged. “I’m afraid the America First militia will be around quite a while.”

“The Americans want to lead the world and they can’t even agree among themselves.”

“And where in the world can you find a country with a consensus? No where. The Grand Union is looking like a grand boondoggle. It was nearly ripped apart by the war and the depression that followed. The geo looked like a great idea until everyone cheated; who knows when the latinero will be reintegrated into it. There isn’t even a timetable, let alone a plan with steps, to replace the other currencies like the dollar. Everyone’s economy is a mess; only India’s GDP is back to prewar levels. The US and China won’t recover for another decade, which generates huge unrest and discontent. Naturally, there are a half dozen terrorist episodes per year in the USA. The Chinese and Europeans have almost as many.”

“Maybe together; they each have three or four per year!”

“Érico, the whole world is a mess. It’s selfishness run amok. Every group within every nation, and every nation in the family of nations, lobbies for its own interests and ignores what’s best for everyone. All the governments are printing money to expand the pie and giving everyone the illusion of a bigger share. But the galloping inflation is impoverishing old people and institutions. A lot of senior citizens would be dead if it weren’t for robotic help taking care of them! University kids have vast debt and no

certain career paths; no wonder 460,000 people applied for 4,000 immigration slots!

Don't tell me things are better in Brazil."

"Well, they aren't too bad there. Unemployment and inflation are both about ten percent; in the US they're closer to twenty-five percent. And our gap between rich and poor isn't any bigger than America's now!"

"Brazil didn't get nuked three times," replied Roger.

"Let me ask you this," said Érico. "You always triumphed individual initiative over collective efforts, both centralized government regulation and socialism. It sounds like you've changed your tune."

"Not at all. Some government is necessary to maintain a level playing field and enforce the rules. That's because of original sin; we're all essentially selfish. But individual effort and initiative, ethically motivated, is always best; socialism is simply a government-imposed solution to the sin of selfishness."

"Well, we're a lot more collectivist than most societies on Earth, and it works fine! And I don't see the churches solving the problem of sin either. How many greedy evangelical preachers are there?"

"There are a lot. I'll concede that. But here on Mars, selfishness could cut off our oxygen supply; we need a much more socialistic framework than terrestrial societies. One persistent problem here, as a result, is an anemic private sector and poor development of basic consumer goods. Religion does help a little, and people are getting religion all over Earth."

"Getting religion? A lot of people are getting rid of religion, too! The churches in Europe are museums. In the US, the percentage joining churches has halved. Even in

Brazil, people have abandoned Catholicism for nothing or for evangelicalism, and now they're abandoning evangelical churches, too! The only groups growing are crazy cults, Muslims, Mormons, and Bahá'ís."

"Well, I have to look at the big picture, Érico. Christianity has served a lot of people for 2,000 years. It has helped a lot of people and it has made the world better. Its job isn't to eliminate sin anyway, just make it manageable until the Lord returns."

"And how will that happen in an interplanetary civilization? I wouldn't want to be caught up into the air here during the rapture! You'd suffocate!"

"I never took that literal reading of the text seriously."

"I'm relieved to hear that. As far as I'm concerned, 2,000 years is too long to wait for any religion to save the world."

"And you think socialistic ideas will do it in less?"

"No," replied Érico. "I don't have a solution for selfishness, either, except rules and government oversight to control it."

"And what happens when governments are dominated by the sin of selfishness? Because that's what we have everywhere on Earth, with moneyed interests buy the elections through skillful marketing. We've held it off here by rejecting nominations and campaigning, but how long can that last?"

"If Earth suffers from enough crises, maybe they'll adopt our system. Who would have thought that letting the people elect their entire government would work, back in 1775? But the US tried it, it worked, and the entire world adopted it."

“I concede that. That’s my second concession to you this sol, Érico! If we can keep our system of elections and it spreads, it could help. And while we’re making concessions, let’s remember this was a religiously inspired innovation!”

“I concede that, Roger. Of course, it was Bahá’í, not Christian!”

“I didn’t say it was Christian. And the Bahá’ís are now large enough to encourage the system.” Roger downed his last drop of coffee. “I think we’ll continue these debates forever!”

Érico laughed. “Forever? Are you suggesting I’ll be in heaven with you, Roger?”

Roger laughed as well. “I’m too old and wise and experienced to say where anyone is going after death, Érico, including myself! Have a good sol, my friend.”

“You too, Roge.”

Roger rose and walked to the counter to return his dirty coffee cup. He stopped at the litter container to drop the napkin he had used. Suddenly, he grabbed the container to steady himself. “Oh oh,” he said . “Érico!” Then Roger collapsed to the floor, unconscious.

“Roger!” Érico jumped up and raced to his friend. The entire cafeteria stopped its conversations and turned to watch. Érico rolled his friend over; his face was turning blue.

“Let me see!” Dr. Tatiana Gavrilova had been eating breakfast nearby. She felt for a pulse on his neck and wrist, then shook her head. “He’s gone.”

“There’s nothing you can do?”

“We’ll try; call the hospital.”

“I still can’t believe it.” It was the third or fourth time Érico had said it.

“There was nothing anyone could have done,” said Will. “It was a coronary thrombosis. At least it was painless and sudden.”

“A blessing,” agreed Ethel.

“I’m afraid it could have happened to any of us, too,” said Sebastian. “Look at us: I’m 81, Roger was 77, Shinji and Madhu are 76, Will’s 72, Ethel’s 71 . . . we’re not spring chickens.”

“It’s not nice to give away a woman’s age,” said Ethel, and Molly, who was 73, smiled. She was the only one present who wasn’t an “old timer” or one of their kids.

“It even makes me wonder,” said Lal. “I’m 67, and I’ve been thinking of retiring from geology.”

“It’s time for all of us to retire,” said Ethel, and she looked straight at Will.

“Pretty much,” he agreed. The others were watching and wondered what that meant. “We can be thankful the rest of us are in pretty good health, and that this world has so many people, we won’t be much of a burden.”

“I’m getting a personal care Jeeves-365 in a few months,” said Sebastian. “I highly recommend them, based on the reviews I’ve read.”

Just then, Madhu entered the room, a space in the basement of the Universal Church of Jesus and the Creator that had been hastily converted into a funeral parlor. She was dressed in black and walked absolutely erect; she did not look bowed, in spite of the shock. “I’m sorry you all had to wait,” she said. “Thank you so much for coming. I can’t tell you how much I value your friendship in a time like this.” Her voice broke a bit. Ethel, Carmel, and Michiko came forward and embraced her, one by one. The men followed and everyone offered their words of condolence.

“I’ll even pray for him, Madhu,” promised Érico.

“You, Érico? I think all of heaven will shout with a great noise and the Creator himself will listen with amazement.”

“Well, perhaps it will be to ‘whom it may concern,’ but it’s the least I could do, for an old friend like Roge.”

“We’ve been praying for him all day,” added Will.

They all followed her into the viewing room, where Roger was laid out in his old naval uniform. Will was surprised by the choice, as it harkened back to a much earlier era, but Roger had never been a member of the Mars rangers and the Exploration Corps didn’t have uniforms. They made a circle around the open casket and bowed their heads toward their friend. They stood in silence; some said prayers silently, including Érico, who remembered the Hail Mary from school many decades earlier. Then Madhu moved to sit, so they all followed and sat in the front row, facing their friend. Reverend Tuesday Nah, chief pastor of the church, sat with them.

“We were wondering whether you’d speak at the funeral briefly,” he said to Will.

“I would be honored to. I’ve been thinking about this matter. Roger was the third Commander of Mars Operations, after Laura and Sebastian. He was acting Commander for only a sol or two; then NASA appointed me acting Commander until Columbus 3 arrived. Nevertheless, he was Commander and deserves a state funeral. This afternoon I signed a proclamation calling for all Commonwealth buildings to fly their flags at half staff.”

“I saw that,” said Madhu. “Thank you so much for that honor.”

“What do you mean by a state funeral?” asked Reverend Tuesday.

“The Commonwealth would pay and it would be large and open to the public. The church probably would be too small; we could hold it in Andalus Square. But the content would largely be up to Madhu, unless you want assistance. If you want a small funeral, you could hold a separate service afterward and before interment. Have you made arrangements?”

“We own a plot in Heavenly Orchard Cemetery,” replied Madhu. Heavenly Orchard, Tiantang Guoyuan Sheng in Mandarin Chinese, was an orchard of citrus and apricot trees filling the small agricultural dome to the south of Cathay Enclosure. The various religious and ethnic communities had cemetery plots between the rows of trees.

“That’s a beautiful spot; we have a plot, too,” said Ethel. She looked at Will and wondered which one of them would occupy it first.

“We could do a large public funeral in Andalus, followed by a small private ceremony in Heavenly Orchard,” said Madhu. “With a procession in between.”

“In Martian gravity, a group of pall bearers could carry the casket that far; it’s maybe 200 meters,” suggested Érico.

“That could be quite impressive,” said Reverend Tuesday. “In traditional societies, the dead were born by their friends to the cemetery until hearses came along.”

“And we don’t have hearses,” added Will. “One could easily find several dozen people seeking the privilege of being pall bearer.”

Madhu turned to Ethel and Michiko. “Will the two of you help Sam and me plan the funeral?”

“Of course!” said Ethel, and Michiko immediately nodded as well.

“Thank you.” She put her hand on Ethel’s shoulder in thanks.

Just then, Sam and Mindy came into the room with Liz and Mike. Sam hadn't yet seen his father since his passing and was immediately stricken by the sight. He wobbled forward; Mindy supported him and even Mike extended his hand. Tears poured from Sam's eyes and he closed them, but didn't sob.

"Oh, dad," he said.

"He lived a good and full life," said Liz.

"I know, but he was too young to go."

"We have no control over these things," said Mike. "Who knows why this happened. There are all sorts of natural causes."

"Especially up here," added Liz. "We don't even know what average life expectancy on Mars will be."

"I know," said Sam, but he closed his eyes and looked down so he wouldn't cry in front of his friends. Mindy held him and then Madhu came over to hug her son.

"We'll get through this, dear," she said.

A thousand people attended the state funeral on Saturdays afternoon in Andalus Square. *Mars This Sol* carried it live as well for Roger's many friends on Earth. Laura Stillwell and Jerry McCord, two Mars veterans who had returned to Earth, taped eulogies. Will praises his friend's virtues as "Marsian, mariner, and human values of the highest order," for Roger had been a loyal supporter, a strong director for Mars surface exploration, a brilliant geologist, a great family man, and an honest, frank advisor. Reverend Tuesday moderated his evangelical language somewhat, so as not to offend the many non-Christians and non-religious who attended. When the service ended, eight pall

bearers raised the casket on their shoulders and carried it through to Cathay Enclosure and south to Orchard of Heaven Dome, a bagpipe in the lead and a procession of nearly a thousand people following behind.

Ramesh Prathan spotted Rajan Yagneswaran, an artificial intelligence specialist, and joined him in the procession. Rajan was the other Indian elected to the Mars Council. “A sad sol.”

“Yes, it is; Roger Anderson was a good man,” agreed Rajan. “Last year we worked together on revising the use of robots and virtual assistants in the field. It was a joy to work with him; he grasped the new capabilities immediately and was quick to propose new protocols.”

“I gather the field geologists are now much more productive, too.”

“Of course! They have several extra sets of hands to collect samples, several extra sets of eyes to make observations, and the new field assistants have lasers, analytical instruments, and sample storage bins built right into them. He was thrilled and went on a special field trip to Ares Valles to try out the new system.”

“I’m surprised he didn’t retire fully.”

“He was working half time, since Madhu retired last spring.”

“There’s been a lot of talk of retirement in the last few sols; several of our older leaders seem to have felt their mortality. I dare say, the voters may have felt it, too.”

“I don’t know; I haven’t heard any rumors,” replied Rajan.

“Oh, I definitely have; that the time to elect a new Chief Minister has come, and this time we need a Chief Minister from India.”

Rajan scowled at him. “Ramesh, you’re just making that up.”

“No, I’m not. I think there’s growing support for Lal.”

Rajan shook his head. “Maybe there is, but it’s inappropriate to say anything.

Really, Ramesh, at a funeral?” Rajan turned and walked away.

18.

Truth and Faith

April 2073

“This is the ski lift speaking. Do you want me to stop completely for the children to get on?” asked a robotic voice, as the Tobin and Anderson families approached.

“Yes, please,” replied Mike. “The same at the top, too.”

“Alright,” replied the ski lift. Mike, Liz, and the 2 ½ year old twins Shayda and Jason approached the triple chair and it stopped for them. They sat the kids and the picnic basket and jumped on; before they could say anything, the ski lift saw they were on and accelerated slowly. Then it stopped again for Sam, Mindy, and Victor—who was also 2 ½--to get on the next chair.

“This will be much more convenient than climbing all the way up,” said Liz.

“It’s public transportation, too; no lift ticket is required,” noted Mike.

“But we will be rather cold!” said Mindy, leaning in closer to Victor, who was shivering in South Baltic’s mid-winter cold.

“But it won’t last long,” noted Sam.

It was a quick ride to the top; the children, though small, were fascinated as long as their parents held onto them tightly. The lift slowed gently and stopped for each family to step off and walk away; they were the only ones on it, because skiing had not caught on yet and in Martian gravity, a one-hundred-meter drop didn’t amount to much. “This way,” said Mike, leading them along a path beaten into the half meter of snow by many

shoes and boots. Jason stopped to scoop up a handful of snow and eat it, then stopped to play.

“No, not now!” said Liz.

They entered the tunnel leading to the pressure suit donning facility and Congo enclosure, bypassing the first and opening the door into the latter. The crisp air of Baltic South, five degrees below freezing, was replaced by air cool to the skin, though pleasant in the sun. “I thought it’d be hot and humid in here!” said Mindy.

“No, this is the dry season,” replied Mike. He led them down a flight of stairs—slowly because of the children—then turned left, rather than right, at the base of the cliff. When they reached the eastern wall of the enclosure they turned and headed downhill—northward—along a narrow trail. In ten meters it veered around a pile of boulders and passed through a little clearing. A picnic table nestled in the shade of trees on the west side.

“Let’s pull it into the sun,” suggested Sam. Mike nodded and the two men picked it up and moved it a few meters out of the shade. Meanwhile, Jason and Victor discovered a cave among the boulders. Mindy looked in; it went only two meters deep and looked solid.

“It’s okay,” she said to the boys, and Shayda squealed and hurried inside as well. “They’re happy!” Mindy added.

“I forgot about the cave,” said Mike. “The floor is flat and dirt; they must have made it specially for the kids. There’s one gap in the rocks.” He pointed to a spot where one could push between two boulders and into the woods. “So we need to keep them

from going there. But otherwise, they can run around in this little clearing and play in the cave.”

“This is perfect,” agreed Liz. “I’m glad you’ve been hiking!”

“The gap between the rocks leads straight into the jungle, and one can wander through to the trail farther downhill, around rocks, trees, and vines,” said Mike. He started to pull sandwiches, fruit salad, cooked vegetables, and potato salad from a picnic basket.

“I’ll have to explore it later; maybe I can bring Vic along,” said Sam. “Any flowers?”

“No, not during the dry season.”

Sam handed Mike a plate; he and Mindy had brought pasta. The kids hurried back once the pasta had come out and they all sat at the table to eat. The kids still needed a lot of help, so that distracted them. “So, are you exploring jungles because you haven’t been out on an expedition for a while?” Sam asked Mike.

“No. In the last year I’ve been focusing on asteroidal magnetism and what it tells us about the solar nebula. I’ll be going on a three-month expedition to a nickel-iron body in 2074, unless the expedition gets postponed again!”

“Two years; a long time. When was the last time you went out on the range?”

Mike thought. “It’s been a year. Why?”

“Because I’m planning a two-month expedition to the central Thaumasia Mountains once the dust storm season’s over, and our paleomagnetism expert—Justin Maneck—just had to pull out.”

“Yes; their pregnancy isn’t going well,” said Liz.

“I’m doing less field geology now,” replied Mike. “And a lot of supercomputer modeling.”

“I saw your paper in *Nature*,” said Sam. “But some field work is a nice complement to computer modeling. It reminds you of the ground truth.”

“Oh, I agree. I’ll keep your offer in mind; I haven’t said no.”

“This is your second trip to Thaumasia, right?” asked Liz.

“Third. Thaumasia is one of the most complex and fascinating geological provinces on Mars. It’s our only collisional plate boundary and the tectonics are extremely ancient. The mineralization processes are unique there, too; terrestrial collision zones today take place in the presence of plenty of oxygen in the rocks, but Thaumasia had carbon dioxide and thus a much more acidic environment. It has lots of spodumene feldspar that can provide us lithium, plus there are deposits of gold, silver, uranium, lead, tungsten, zirconium, uranium, tantalum, tin . . . it’s very rich, but the deposits are scattered.”

“So: a future outpost?”

“Probably, but one that will work only if it has lots of good roads because the deposits are so scattered. I think we have a possible central location for an outpost, where spodumene, gold, and tungsten are within a reasonable driving distance. We’re going in to explore the field geology of that area intensively and refine possible plans.”

“He’s been fascinated by it,” added Mindy. “It was a fascination before his dad’s passing, but since it has become a bit of an obsession.”

“I suppose it’s my way of coping,” said Sam. “He accomplished so much in his life. I feel . . . like a pale copy, sometimes.”

“You shouldn’t,” replied Mike. “You’re Sam Anderson, not Roger Anderson, and you can never be Roger Anderson. You have your own path, the path of an excellent field geologist and Mars explorer.”

Liz put her hand on Mike’s shoulder. “You are right, but you don’t completely understand. Many members of the second generation feel that way.”

“People tell us again and again not to compare ourselves to the first generation, but it is inevitable that we do,” replied Sam. “And when we do, we see that they established a beachhead on a new world and built a society there, and we didn’t. Of course, Marshall is an exception; he got to go to Titan. But that makes the rest of us feel more inadequate, not less.”

“Especially you, Sam; the two of you were schoolmates from kindergarten through twelfth grade, and no one else was in that class,” said Liz. “But again, you’re Sam Anderson, not Marshall Elliott.”

Mindy put her hand on Sam’s back. “They’re right.”

“I know they’re right, but it doesn’t complete help!” He paused to calm down. “Dad was so certain; in himself, in his faith, in the way the world is. Mom is, too. Her world has been badly shaken by dad’s passing, she has withdrawn from her projects for a while, but she still has her faith. But I just can’t have that kind of faith. I still go to church sometimes, bow my head during the prayers, listen to the sermon, and there’s no feeling, no faith; nothing. It’s the way I am.”

“Sammie, so what?” said Mindy, holding his hand. She had never been a church goer, and neither had her parents. But his comments were directed at Liz and Mike.

“I think you are linking faith in yourself with having a faith,” replied Mike. “And while I have both now, several years ago I had plenty of faith in myself but was an agnostic, even an atheist. So I think you should realize and accept that you are an extremely talented and intelligent man, an experienced and sharp field geologist with a real knack for field work, a well published scientist, a popular teacher when you teach at Martech, well respected by your colleagues and entrusted with the responsibility of leading expeditions, and besides you are happily married with a loving wife and have an energetic son, you are a good father and husband . . . these are accomplishments that, taken together, are impressive and worthy of someone who is 32 years old. When your father was 32, he hadn’t landed on Mars yet and he hadn’t started a family.”

Sam thought about Mike’s comment, which made an impression on him. “Fair enough,” he finally replied. “But part of the problem is caused by my upbringing. I feel guilty about my failures; my sins of omission as well as my sins of commission. And so far, no matter how hard I have tried, I haven’t been able to shake the feeling that I fall short.”

“That you’re going to hell,” injected Mindy.

“Yes and no, because I can’t believe in hell. There are people in the church who believe there’s a spot inside Mars with fire and brimstone, just like inside Earth! Absolutely absurd!”

“But regardless, Sam, you may not believe in a physical hell, but you still fear a metaphorical one, I think,” said Liz. “Call it separation from the God you can’t know, or separation from your parents who might be in a better place after death because they have

faith . . . this still weighs on you. It always has, since you and Corrie broke up, and maybe before that.”

“Oh, way before that.”

“You know, the Bahá’í teachings about this make so much more sense,” said Mike. “People are not consigned to places called heaven or hell after death. They progress infinitely and eternally in the next world. Any deficit here—and we all have them—will be made up eventually. We learn and we grow. And we make mistakes, too. When you come to a moral fork in the road, you can dwell on the wrong choice and worry about sin, or you can look at the choice as a spiritual test you will have to pass eventually, no matter how many times you go down the wrong road. It replaces guilt with hope and a desire to strive.”

“I very much admire your Bahá’í teachings,” said Sam. “Some of the ethical principles are rather amazing; your recent Spiritual Assembly elections were covered a lot on the media and are very impressive. But I don’t know how I can live some of the more challenging principles.”

Mike laughed. “And you think we can? I used to fret about having to stop drinking, but that’s nothing; how do I stop gossiping and holding grudges? And how do I know when to speak and when to hold my tongue?”

“That’s his big problem,” agreed Liz, with a smile. “Mine is the opposite; speaking up!”

“You know, our aunt Molly is holding all sorts of spiritual education classes,” said Mike. “She just finished one on spiritual elections and had several dozen people in it, most of whom weren’t Bahá’ís, but who wanted to understand the ethics of our elections.

She's starting one on prayer and the afterlife on Saturdays in the classroom in the basement of the Bahá'í temple. Ananda runs a class on virtues Thursol evenings, too. A class on teaching children spiritual matters starts soon. All sorts of people take them, they're free, they're fun, and there's no obligation. A few people become Bahá'ís, of course, but most people just want the perspective, and that's fine with us."

"I've heard of the classes," said Sam. "And they have been pretty popular, over the years. I admire the educational approach. All the faiths have pursued it, and I think your classes stimulated it."

"We focus heavily on education," agreed Liz.

"You know, it would do you good," said Mindy. "If you don't like your evangelical upbringing but you can't shake it, try some new ideas. I'll go with you, if you'd like."

Sam wavered. "Well, maybe."

"We can bring the class to you, if you prefer," said Mike. "I've taken it and Liz took it some time ago, so either of us can facilitate it. We could do it on a weekly picnic, if you want."

"Maybe we should try that," agreed Sam.

"Thank you so much for giving me another chance to work on safety issues," Rachel Evans said to Will. "It has always been my first love. When I resigned as Mayor of Uzboi, I really wasn't sure what I'd do next. I think my approach to safety is much more pragmatic and experienced."

“As mayor of Uzboi for five years, you have seen matters from the other side,” said Will. “Safety is always a balance of protection, cost, human resources, and how fast you can change culture.”

“Exactly. If we wanted to maximize safety, we’d stay on Earth! I think you’ll find that my suggestions are fairly practical.”

“Well, tell me what you’ve got, then.”

“Alright. You asked me to look at the safety of the new enclosures, vehicles, and safety as it relates to Ceres, Phobos, and Uranus. The engineering audit of the enclosures was conducted by a very capable engineering firm in Germany that was involved with the design and construction of Peary. They looked at the fabrication techniques and all the records of tests of materials and of the construction. The safety factor of Caribbean and Mediterranean is excellent; the overdesign is 335%, not 300%. It is sufficient for a Marsquake of magnitude 7, which should occur here less than once every 10,000 years. With a regular maintenance schedule to guard against fatigue, the enclosure should be good for at least fifty years. So the engineering is not a problem; the goal is to reduce risk below one in ten thousand, and that has been accomplished. But even with walls around the dome to protect it from vehicle collisions, there is still the possibility of an aerial crash into it by a spacecraft or jet, and such a crash would rip such a huge hole in the dome that the whole thing would deflate in a few hours. The chance of that is hard to quantify, but it may be more than one per ten thousand. For that reason, the safety team recommends that future domes, regardless of width, be subdivided into airtight compartments. That’s especially true of the enclosures planned for Cassini, Dawes,

Uzboi, and Tithonium, which will increase their polder by 200 to 500%. That's too many eggs in one basket."

"I agree, and those plans worried me. What about Caribbean and Mediterranean?"

"Caribbean and Mediterranean represent 14% and 28% of Aurorae's polder respectively, and the chance of both being punctured at once is far less than one per ten thousand. Consequently we see no need to retrofit them. When Caspian, Atlantic, and Pacific are completed, their portion of our space will shrink. But the new ones should be subdivided at least into halves for safety purposes, and the two parallel public transportation tunnels should not cross the same enclosure."

"Ramesh will be furious, but I agree."

"If he's furious, it's just ego. The redesign is not extensive and the cost increase will be less than ten percent. There is nothing wrong with the engineering or the construction techniques. It's a question of reducing the chance of an agricultural crisis below one in ten thousand.

"Regarding settlements dependent on gravitied accommodation, our conclusion is simple and in agreement with the various critics who have commented from time to time: such settlements need a minimum of three separate rotating spaces. We add that missions of duration longer than five years should have at least three separate vessels if they use the present design where the exterior of the spacecraft is stationary and the interior rotates. If the entire vehicle can rotate, that's different, but currently caravels and galleons are not designed that way; they have zero-gee cargo accommodation and nonrotating interplanetary communications equipment on the outside. Allowing the outside to rotate in an emergency situation is a moderately expensive redesign, but it's important;

long-duration exploration requires artificial gravity. While the current design is quite robust, a meteor strike or explosion could easily compromise it and can't be designed against."

Will pondered and nodded. "That will be controversial and expensive, but I agree with you. Ceres and Titan are getting their third rotating spaces in the next year and Callisto will get a third in two years. This means the Uranus mission needs three vessels."

"Definitely. Phobos has three and Parenago apparently will expand to three in a few years. But plans to give Magellan Station a galleon should be scrapped in favor of two additional caravels."

"Okay. What else?"

"We looked at the plans to expand Acheron Outpost to have a minimum of two hundred square meters of ecology per resident and to introduce a bioarchive component. We strongly endorse their conclusions. Any outpost that is more than a few months from another outpost needs very, very robust ecology to guarantee safety. The Uranus mission needs to be designed with a minimum power output of about 125 kilowatts per person. Ceres will need a series of large surface enclosures with mirrors to concentrate sunlight."

"Again, expensive."

"Yes, but the result will be a much better psychological environment. People will feel safer and more comfortable, so they will be willing to stay longer. That will reduce crew rotation and resupply requirements and save some money."

"Have you considered the minimum size of a remote society?"

"No, that's not a safety issue per se, it's a sociological one. But three galleons will hold 450 people, 600 with a conical with zero-gee horticulture and work areas. Three

corvets would double that number; 900 to 1,200 people. Settlements of that size would be substantially self sufficient. If you could wrap a couple thousand tonnes of shielding around them and accelerate them to ten percent the speed of light using a fusion engine, you could send them to Alpha Centauri in forty years.”

“And in another generation, our life support systems could be reliable that long.”

“Before we try anything like that, we’ll want to send out ten or twenty-year missions to the ice worlds in the Oort cloud. A Neptune mission with a base on Triton would be the first, a mission to Pluto second, and after that, who knows? Such missions will need large crews, long-term self sufficiency, and multiple vehicle redundancy. Crew rotation flights that take longer than six months should also be accomplished using at least two vehicles, for safety.”

“Two or three caravels rather than one galleon.”

“Exactly. Caravels and galleons are designed to have a series of separate sections with independent life support systems, but a meteor strike or explosion could damage several of them. Two vessels will have more sections and more ways life support can be maintained.”

Will nodded and pondered the proposals. Rachel shifted in her chair nervously. “I don’t know how practical these applications are right now. They’ll create enemies for you.”

“They will, but that’s alright. I have a lot of accumulated trust and good will that I can expend, and I’ll expend them on this. We need to begin implementing them right away. The next step, I think, is a more detailed presentation by you and your team to the entire cabinet and a few other people, such as the heads of Marbuild, Marfab, and

Marcraft, for example. Then the entire report is published so everyone can see it. Can we do that next week?"

"Next week? That is fast! I think we'll need two or three weeks to finalize the text of the report. But who will implement the new safety guidelines? The Directorship of the Office of Safety is vacant."

"Do you want the job back? You had it for several years under the Mars Commission, did a good job, then left honorably because you got married. Your replacement was capable, but wasn't sufficiently active. We need an efficient, almost aggressive office that will sniff out problems before they happen, describe the potential bad scenarios in detail, and propose solutions. We can't be changing the rules every few months, but we need to schedule safety improvements and roll them out gradually."

"We need more depressurization and fire drills, too. Once a year is not enough."

"I think that's true. Will you take the job?"

Rachel thought about it, then nodded. "Yes, I will. Is this a cabinet-level position?"

"It was before, but I think we need to consider a different model; more like a government bank, an independent governmental agency whose head is not a political appointee. We don't need a safety officer injecting caveats during brainstorming sessions, for example, but critiquing the implementation of the plans afterward. That's the proper role."

Rachel nodded. "Alright. Give me three weeks to get the report finalized, and a month to move here from Uzboi. My husband wants a new job anyway; assuming he can find something here, all will work well."

“Alright. Excellent.”

“I couldn’t believe the accusations made against President Mennea,” exclaimed Greg Harris, as he and Bishop Karol Miller walked across Andalus to visit a sick parishioner.

“It’s shocking that a lie can go so far.”

“The America firsters have decided it’s all they have, I guess,” replied Karol.

“They can dominate their own media outlets, and their faithful, which number maybe fifteen percent of the American population, tend to believe anything they say.”

“Still, how can you open an impeachment investigation based on false charges of treason?”

Karol shrugged. “If you repeat the same charge day after day, some people will believe it, even if it’s false, and they’ll donate money to your cause. That’s what the politicians on Earth have discovered in the last few decades. But let’s not worry about politics.”

“Father, we have to worry about politics when it produces injustice. These are the sorts of lies that started the war between the United States and China.”

“I agree, and I didn’t mean we shouldn’t worry about politics at all, just not right now. So, what can you tell me, confidentially, about Monica’s prognosis?”

“We definitely need to pray for her. They found the cancer just three weeks ago; a uterine tumor the size of a large grapefruit and growing very fast. She just had a baby four months ago and it wasn’t there then. The hormone treatments probably stimulated it. It’s stage 4, too; it’s spread to the intestines. They’re going to give her a very powerful

new chemotherapy drug designed specifically for the DNA of the cancer. They think there's a ninety percent chance that'll eliminate the cancer."

"That's good. It's amazing how powerful and specific the chemotherapy drugs have gotten. So, they don't think this was caused by radiation, Martian dust, or any other environmental factors?"

"No, it's probably connected with the fertility treatments."

"I suppose that's a small consolation. She's such an incredible person, such strong faith and devotion! I hope this terrible event strengthens her."

"So do I, and I suspect it will; she's resilient. She also was one of the few volunteers the church had."

"That's probably over because of the baby, anyway. People work too hard here and have too little time for other things."

"That's very true." Greg saw Molly Nuri walking toward them. "Ah, speaking of volunteers; the person who does half the work of the interfaith council."

"And half the Bahá'í work, I dare say." Karol raised his hand in greeting. "Good sol, Molly," he said, as they approached.

"Good sol, Father. How are you this morning?"

"Quite well, off to visit a parishioner who's stuck at home. How are you?"

"Well and off to help someone with her English. How are you doing, Father Greg? How's the family?"

"We're all well. Wicahpi-luta's finishing his third year of Martech in a few weeks; it's hard to believe!"

"It is! And Maaka's on Phobos, right?"

“Yes, an electrical engineer building galleons. How are your classes going?”

“Pretty well. I’m about to start a new class on prayer, study of scripture, and the afterlife for a dozen people.”

“How did your class on spiritual elections go?”

“I think it was pretty successful. We held it in April, just before Bahá’í elections on April 21, because we had a dozen or so new Bahá’ís and many wanted to understand the process. But I had twenty in the class, and only five were Bahá’ís; the others just wanted to understand how we elect our governing bodies, and why. I think it was quite successful at answering their questions, too.”

“Yes, and I heard from one parishioner who attended that some people became interested in your faith, as a result.”

“That’s true, though that wasn’t the purpose of the class.”

“Why don’t you schedule the class again for the fall, before our national elections? I bet it would help people understand the Marsian approach, because it is rather similar.”

“I have been thinking that it would make a useful contribution to public discourse about governance. The curriculum would require some modification, but that wouldn’t be too difficult. Thank you, I’ll consider it.”

“Good, I think you should. I’d even like to see the materials myself, because I think a Christian perspective on spiritual elections is possible, too.”

“Really?” Molly wasn’t sure what she thought of that. “The current materials are on the web; I can give you the address, if you want.”

“Please. I’ll send you an email and ask.”

“Alright. Have a good sol, gentlemen.”

“Same to you, Molly,” said Karol. They nodded in good bye and continued on their way. “Why do you want the materials?”

“I think the Bahá'ís are very clever,” replied Greg. “Their focus is on making people better human beings through spiritual education. They have dozens of different classes open to anyone; in fact, one of our parishioners is teaching one of them, because anyone can be trained to teach them! As a result, they’re slowly shaping culture. We need to do the same.”

“That’s why we’ve been sponsoring conferences.”

“The God on Mars conference was a great success, as have the two conferences since. But we need more than conferences and Bible study. I think we can do a class about spiritual elections, for example.”

“I wouldn’t go there! We have to stay out of politics!”

“That’s not what I’m talking about, Karol. How about the Ninth Commandment: ‘Thou shalt not bear false witness’? That’s what’s happening to Mennea!”

“And all over Earth; but what else is new? Politicians have been bearing false witness since the beginning of time!”

“Maybe it’s time to call them on it. There’s not much of it here. Catholic materials developed and tested here can help change the culture on Earth.”

Karol considered that a moment, then nodded. “Alright, develop something and let me take a look. I doubt the Vatican will approve. But it’s easier to ask for forgiveness than permission.”

“Okay.” Greg looked back to see where Molly had gone; he was pleased he would be pursuing the idea. Molly disappeared around the corner, where she walked down an alley to the back of the building marking the southern edge of Andalus Square. Devika Chandrakar was watching for her and headed for the door of her apartment when she saw Molly walk through the main entrance. She opened the door and stood in the hallway waiting for her friend.

“Devika, good sol!”

“Good sol, Molly! I have your tea ready.”

“Thank you, you’re very kind.” Molly walked up to Devika and they embraced, then both entered the living room. “How are you doing this sol?”

“Pretty well. Rajiv has a literature presentation due tomorrow, so I’m nervous about that.”

“You don’t need to read everything he reads; he’s in 7th grade and can read it himself.”

“Yes, but as you know, my English is limited and I really want to be able to help him.”

“Your English is fine! But let’s see your questions. What book?”

Devika pulled out her tablet and showed Molly her questions, which were headed on top by the author and title of the book, while Devika brought over the tea. It was a recent novel about children growing up in Ethiopia; very popular as a middle school literature assignment. “Did you know Sonya Anoshkin is writing a novel about Marsian children? Won’t it be nice to have our own contribution to children’s literature?”

“She was Rajiv’s teacher last year. Yes, that will be very good. I bet the kids will love reading it, too.”

“They’ll wonder whether any of the characters are them in disguise,” said Molly with a smile. “These are very good, thoughtful questions. I can’t help much about plot or characterization; I haven’t read the book. But I can help go through some of the slang and unusual terms.”

“That’d be great, thank you.”

Molly took a sip of her Indian tea, paged through the book on the tablet, and they discussed the first word Devika asked about. In 45 minutes, they went through all 25 words she has singled out and had figured out a few of the literary questions as well. “You are going to be the most literary virtual business hostess on Mars!”

Devika laughed. “Well, there are only four of us, and only one at any particular time! Did I tell you that we now have the contract for Deseret as well as Silvio’s, and Cinq à Sec will probably sign on as well? We’re hiring three more people once they start arriving early next year because we need to have two on duty at any particular time.”

“So, will your company be providing hostessing for everyone?”

“Just about; we’re the backup for Deseret, which will continue providing one person live in their Aurorae store, who will also provide customer support by video in their Cassini, Dawes, Uzboi, and Meridani stores. But we’re it for Silvio’s stores outside Aurorae; the person here is too busy to monitor the other stores. We’re also customer support for Marfab.”

“So much to know about! And you think your English isn’t enough and your education is lacking!”

“Well, I’m probably the only adult on Mars without a college degree! That’s pretty intimidating.”

“It shouldn’t be. How many women do you know who can open a business like yours and raise a thirteen year old without help from a husband? I am in awe, Devika!”

“Thanks, Molly. I’ve often wondered whether staying, after he divorced me and returned to Earth, was such a good idea. But it has worked out, I think.”

“I think so. Does Rajiv talk to him?”

“Two or three times a week they exchange audio emails. He refuses to look at his dad, but at least he listens to his voice.”

“Does he have any men around? At that age, a boy needs a role model.”

“Not really. If Paul could spend some time with him, that might help.”

“But Paul’s 43; maybe a younger man would be better. There’s no one in the Hindu community?”

“Probably, but they’ve never been very friendly or helpful to either of us, I’m afraid.”

“I’m sorry. I’ll ask around. Would he enjoy participating with the Bahá’í junior youth? We have quite a group.”

“You know, that might be good. He knows them all at school and he’s mentioned one to me; Agostino?”

“Probably John Agostino; he’s thirteen as well. I’m sure Rajiv would be welcome. Our junior youth group is not just for Bahá’ís. Its purpose is to help 12 to 14 year olds plan for a lifetime of service to others. They study, socialize, and do volunteer work together.”

“I think he’d enjoy that, if it doesn’t conflict with junior varsity soccer. But I think John’s on the team, so I guess it couldn’t. You’re starting up a new class soon, aren’t you? Because I’d like to go, and maybe go to a Bahá’í gathering as well.”

“Excellent. We have three holy days in May; three out of nine! So there are several chances to come worship with us. My class starts next week; Tuesday at 7:30 p.m. at the temple. Feel free to come, there’s still room. It’ll focus on prayer, study of scripture, and the afterlife.”

“That’d be good.” Devika paused. “I feel a certain . . . spiritual vacuum in my life, I think. Work is good, raising my son is good, but neither is ultimate or eternal. I suppose that sounds silly; what *is* eternal? Of course, as an Indian I’m worrying about liberation from suffering and the cycle of rebirth. Even when I say I don’t really believe in them, I sort of believe in them anyway! Do you know what I mean? These are ideas in me, and they set up a certain yearning.”

“Yes, I do think I know what you mean. We are spiritual beings; we have to yearn for contact with God, for a relationship with God, even when it seems impossible. It’s how we are made. I think my class might be able to help you because it deals with that yearning directly.”

“Good, I’ll come to it, then.”

Safety Guidelines

June 2073

“Big, shiny, and metallic,” said Yuri, staring at the gigantic chunk of nickel-iron meteorite, some ten meters wide, high, and deep. He had joined Marshall, Sridhar, Rahula, and several geologists in the new SS-4 cavern, fifty meters high and wide but not yet one hundred meters long because they encountered the chunk three quarters of the way down. They were all wearing outdoor gear because the cavern was seventy-five below Celsius—slightly closer to Earth normal than Titan normal—and had a pure nitrogen atmosphere, except for stray methane leaking in from the ice “bedrock” and carbon dioxide gas escaping from their helmets.

“We knew it was here,” said Sridhar. “The magnetic anomaly was pretty obvious. There’s another, bigger one about one hundred meters that way.” He pointed to the far end of the cavern and slightly to the right.

“This is regular nickel iron?”

“No,” replied Marshall. “Ataxite. From an optical examination using hand lenses, it appears to be about eighty percent nickel. We’ll need to complete a chemical analysis to determine how much Platinum-group metals it has, but’s probably in the vicinity of 300 grams per tonne.”

“And it masses about 4,000 tonnes, so it has a tonne or so of PGMs,” said Sridhar.

“So, we can go into the PGM exporting business too, in a small way!” said Yuri, smiling. “It’s pretty unusual to find nickel-iron out here.”

“This is a chunk broken off a main-belt asteroid,” agreed Marshall. “Then Jupiter perturbed it, it got flung out as far as Saturn, and it encountered Titan. Our atmosphere is so thick, the body broke up into a series of pieces, and when they hit the surface they made relatively small craters that filled in. I doubt we’ll find many pieces; there aren’t many magnetic anomalies around here.”

“What’s the chance of finding a big ataxite body on Titan?” asked Yuri.

“Pretty small; we’re too far out,” replied Marshall.

“Export costs would be high, too,” added Sridhar. He pointed to the chunk. “We can smash it into little pieces and run it through our carbonyl fractionator. We’ll end up with a very high nickel alloy that we can use it in construction. Shall we go after the other chunk?”

“It’s not in one of the projected caverns, like SS-5?” asked Yuri.

“No, it’s beyond the end of SS-4 and in the middle of the wall between it and SS-5.”

“Then let’s reorient the bioarchive caverns so we can obtain the other chunk,” agreed Yuri. “How soon before this cavern is excavated?”

“We have two weeks of melting left, then several months of work to install the airtight nickel-steel shell, then the biologists can take over.”

“Good,” said Yuri. “This ataxite body will speed things up; we’ll have that much less nickel-iron to excavate outside.”

Helmut looked up from the safety guidelines on his tablet and looked at Jack Alberghini and Adam Haddad. “This is amazing. What do you think?”

“It’s a lot of construction!” said Adam, who was in charge of construction. “Two hundred square meters of horticulture per person and one hundred people; that’s 20,000 square meters or two hectares of farmland! Right now we have a third as much. And we’ll need three times as much low-gee space as well.”

“They’ll send us the bubbles, though,” said Helmut. “And with the new conical addition to caravels and galleons that can be dismantled, they’ll send us the low-gee accommodation as well. I bet we won’t have a huge amount of actual construction.”

“So, we’re doubling in population and tripling in size,” said Jack. “That’s incredible.”

“At least,” replied Helmut. “Because they plan to send a galleon after the *Bode* arrives. We need at least 125 people in order to export 100 tonnes of PGMs per year. And as this report says, we’re a long way out and completely on our own, and we’re using equipment that has a ten year lifetime while we plan to stay indefinitely. These are reasonable, even generous, safety guidelines.”

“I think we need to plan on more than 100 tonnes of PGM exports per year, though,” said Jack. “Because even if Mars provides agricultural bubbles and inflatable zero-gee accommodation, we’ll still have to pay for them eventually.”

“That’s true,” said Helmut, reflecting on the point. “Which means we’ll need to expand even more, near term, to provide the income to explore the Belt.”

“These new standards are important for livability,” exclaimed Adam. “Half our population goes outside once a year or less. Only ten of us go outside once a month or more. This is a small place for raising kids, and much of the population that came here was selected because they had already had children or weren’t planning to have any.”

“That has now changed,” said Helmut. “The crew of the *Bode* is young and we didn’t ask them about family plans, and we won’t ask that any more. So we need more space. What did you think of the proposed additions to the safety regulations?”

“They’re better than anything that comes from Earth!” replied Jack. “They were developed in close cooperation with the personnel on Phobos. The analogy isn’t exact, though; we’re in a minigravity environment, not a microgravity one. We need to try them out and propose modifications.”

“Let’s talk to the crew of the *Wolf* as well,” suggested Helmut. “Lutetia’s gravity is 0.005 gees; the Trojan asteroids they visited were similar. They’re the experts about minigravity. We can develop a comprehensive set of exploration protocols that will work for most of the bodies in the Asteroid Belt, not just on Phobos and Ceres.”

“We need that, if Ceres is to become the center of exploration of the Belt,” agreed Jack.

“Elliott’s out to get me. I’m sure,” said Ramesh to Lal Shankaraman and Siddharth Swaminathan, the Hindu temple’s priest. “These safety guidelines; they’ll *ruin* the big enclosures!”

“Ruin them?” said Lal, puzzled. “The report calls for inserting one or two pressure curtains along the length of any new enclosures where there are already pylons. You’ll have to drive in a few extra pylons and add some cables and a curtain of dome material. None of the existing domes require retrofitting. You’ll be able to see through; you’ll preserve the sight lines. You can look at it another way, too, Lal: this allows enclosures of infinite length! The end just becomes a temporary pressure curtain.”

“Maybe even infinite width,” added Siddharth.

Ramesh shook his head. “No, a pressure curtain does not preserve a sight line; it interrupts it. Pure and simple. These are *elegant* designs, and they’re perfectly safe!”

“The report doesn’t say they are unsafe, Ramesh,” replied Lal quietly in an attempt to calm his friend. “It says that if an air crash happens, no design that can retain pressure is possible, so the large enclosures need to be divided into a series of airtight cells, especially at other outposts where one large enclosure will contain more than half the outpost’s polder. No single enclosure should contain more than ten percent of any particular outpost’s polder.”

“When the first four enclosures were built, the standard was 25%! Even as late as the inflation of Ukraine, we were making expansions of as much as thirty percent at once!”

“Well, now we’re bigger, the place is more complex, and we’re being more careful,” said Siddharth.

“So what if you divide Atlantic and Pacific into thirds?” said Lal. “At that point, how big will Aurorae be? Two, two and a half million square meters? A single enclosure the size of Caribbean would be less than ten percent and wouldn’t have to be divided! So you’ll get your long sightlines soon enough, especially if immigration keeps growing exponentially. In a decade we may have immigration rates of 25,000 per columbiad.”

“If such immigration is technologically and financially feasible. I have my doubts,” replied Lal. “No, Elliott has a prejudice against my ideas. I feel it.”

“Ramesh, have you looked at the rest of the safety guidelines?” asked Lal. “I spent all afternoon reviewing them. Phobos needs an extra galleon for emergency housing

and another extra galleon for housing immigrants, at 800 million redbacks each. That's a huge investment. The spaceports need to be moved ten kilometers farther from the outposts; that's a real pain, and expensive. Everyone needs to increase their solar and wind power production to maintain better margins, and everyone needs larger oxygen and methane storage. That's another 2 billion redbacks over three annums. The transport capacities of caravels and galleons have been redefined, and they're a bit lower, with more volume per passenger. The bigger safety margins are going to cost us big."

"We've been lucky so far," said Siddharth. "No shuttles have crashed; no interplanetary transport has had a serious crisis. These guidelines may even save money in the long run."

"I agree," said Lal. "A big crisis could cost even more. Mars needs to have a mature governing system that anticipates problems, rather than reacting to them."

"As soon as he saw Caspian, he expressed concern," replied Ramesh. "He didn't wait to hear my explanation. He has a prejudice against big structures!"

"Well, tell you what," offered Lal. "Next time I see him, I'll ask."

Ramesh frowned at that. "Look, we need to work to get rid of him. How long has he been in charge of Mars? Thirty years! Even monarchs rarely reign that long!"

"He hasn't exactly been in charge all that time," replied Lal. "He wore different hats, sometimes being in charge overall, other times of just surface operations. He's so influential, Ramesh, because he has a vision and ideas how to implement it. He's persuasive."

"And he overrules other people's ideas! Look, we need to talk to more representatives on the Mars Council. They need to vote for you, Lal."

Lal shook his head. Siddharth leaned in close. “Ramesh, are you electioneering?”

“I am, and don’t tell me it’s wrong, because it isn’t! We have a right to talk about who we think should be elected!”

“You do indeed have that right in every country on Earth that isn’t a dictatorship, but we are more refined up here.”

“Refined? Is that what you call someone running Mars for thirty years?”

“Look, Ramesh, I think there is every reason to assume this is Elliott’s last term,” said Lal. “I see him every sol or two. This safety revision looks like the final act of someone who is expending political capital. If he stands for a third term as Chief Minister, he’ll have served twelve years and will be seventy-seven. I don’t think he wants to set the precedent of three terms, and I don’t think he wants to be running things at that age.”

“Well, if we kick him out of office, we won’t have to worry about either.”

“Ramesh, jealousy is exactly the problem with terrestrial politics, and no one wants to see it imported to Mars,” warned Siddharth. “You complain that Elliott has a bias against you; you certainly have a bias against him! I think you should mediate on that and work on yourself. If he has a bias against you, that’s his spiritual illness, and it shouldn’t give you the same illness.”

“I can understand feeling hurt about the design changes in your enclosures,” added Lal. “But you can always appeal them. I’d do that and see what everyone says. Elliott changes his mind, you know.”

“Maybe.”

“And don’t campaign for Lal,” added Siddharth. “It’s illegal and unethical.”

“It is not unethical, based on Hindu teachings.”

“It is unethical on Mars, and don’t be so sure Hindu teachings support campaigning. It’s hardly a hot topic in ancient texts, but they have a lot to say against rivalry and speaking untruths.”

“No one in India has been saying campaigning is wrong.”

Siddharth waved at Ramesh’s food. “Eat your pocha,” he replied. He was tiring of arguing. “How’s Crystal?”

“She’s at home and she’s fine. I’ll grab a taxi as soon as we’re done here. Canyon Meadows is now easy to get to.”

“And when’s the baby due?”

“Two more months. We’ll move back here and stay in the Marriott starting next month so we won’t have any trouble getting to the hospital when the time comes.”

“I saw Sarah and the twins the other day; they’re getting so big!” said Siddharth.

“They just turned seven. I see them two nights a week.”

Just then, Amalia Dewanji, a Swedish biochemist married to a Bengali software engineer, entered Punjab Square with her twelve year old son, Jaidev. Mother and son were both blonde. “Do you want to perform puja?” asked Siddharth, rising from the table. They came to the temple three times a week for a brief worship of Ganesh.

“You’re eating? We’ll stop by on our way back from Andalus,” she replied. “We don’t want to interrupt your supper.”

“We’ll see you later, don’t worry,” added Jaidev in Hindi.

“Okay,” said Siddharth, with a smile. He watched them walk out the other side of the square.

“Did Aditi stop by this sol?” Lal asked Siddharth, referring to his 26 year old daughter.

“Yes, and she helped me wash the images very well. She is such a sweet girl; so helpful.”

“I know, she is a blessing.”

“Is she working?” asked Ramesh.

“Yes; the cafeteria has given her a job in the kitchen helping with the dishes. There are some things she can do that robots can’t.” Lal looked at Ramesh, irritated that their chief construction engineer was asking questions about his Down syndrome daughter. “She has finished a high school education, you know.”

“Oh, I’m sure. I meant no offense, Lal.”

“I’m sure you didn’t,” Lal replied ambiguously.

Ramesh turned to his supper, wishing he could finish his meal quickly and leave. Then he saw Devika Chandrakar and her son Rajiv come across the square, heading for the Indian food store. He waved to them. “How are you?”

“Pretty well.” Devika and Rajiv stopped, though the boy looked a bit nervous.

“Did you want to perform puja?” asked Siddharth.

“Perhaps another time,” replied Devika, with a smile.

“But mom—” objected Rajiv.

“Another time, dear.”

“But I don’t want to—”

Siddharth was puzzled. “I can go over now—”

“No, this isn’t a good time,” apologized Devika.

“We’ve become Bahá’ís,” said Rajiv suddenly, boldly.

“Oh?” Siddharth was surprised.

“But we can still come to the temple to pray,” said Devika. “And we will be pleased to do so.”

“Thank you,” said Siddharth, embarrassed.

“It’s good to see you gentlemen. Good evening,” said Devika, heading for the store. Lal and Ramesh nodded to her. They watched mother and son leave.

“Bahá’ís!” Ramesh almost spat it out. “Molly Nuri, Elliott’s sister; she’s been meeting with Devika to help her with her English.”

“What’s wrong with her English?” asked Lal.

“Exactly!” said Ramesh. “She has taken advantage of this poor, single mother and child and converted them away from Hinduism!”

“Calm down, Ramesh; this is a free country,” said Lal.

“That’s two less people coming to the temple, and the loss of a member of the next generation.”

“Not necessarily,” said Siddharth. “This is not India, Ramesh. I serve blonde Hindus like Jaidev. And are your kids Hindu? Your first wife was a Catholic Indian and your second is an agnostic from Argentina.”

“Maybe we should complain to *Mars This Sol*, though. It doesn’t seem right.”

“I suggest you ask her first whether she feels exploited or fooled, or you’re the one who will look like a fool,” replied Siddharth. “I’ll talk to Devika.”

Will entered his house slowly. Liz immediately noticed the lack of spring in his step.

“You look tired, dad.”

“I am. I hope I’m not late.”

“No, right on time,” said Ethel.

“The food hasn’t arrived yet, anyway; the delivery is running a little late,” added Mike.

“Here, sit,” said Molly, pulling out a chair at the table for him.

“Thanks.” Will sat. “I’m worn out. It’s always hard doing something unpopular.”

“The safety revisions?” asked Mike. “Most of them don’t even go into effect for a year, so there’s time for discussion.”

“Well, discussion has begun! The Mayors of Cassini and Dawes called me in a conference call to express their concerns because the cost of gold extraction will go up. The machinery will need inspections more often, the gold pits will need stronger wall reinforcement, the cost of power will go up a bit . . . they think the current standards are fine. But who wants to find out the hard way that safety standards need strengthening!”

“Of course, you can make them too strong, too,” said Ethel. “If there are never accidents, you don’t know whether the standards are just right, or twice as strict as they need to be.”

“That’s true, but there are always minor accidents, and you can extrapolate from them how often serious accidents will occur, if the model is right,” said Will. “I can’t say that the model is right, but we’re refining it all the time, and there is a discussion period, except for safety regulations we are relaxing; there are some of them, too.”

“PGM production costs will rise five percent,” said Ethel, in a neutral tone that implied her concern as well. “But we’ll still make plenty of profit for Mars.”

“How much are we producing?” asked Liz.

“We’ll finally produce a thousand tonnes this columbiad; that’s 450 tonnes per year,” said Ethel. “Next columbiad, we should reach 1,300 tonnes. Parenago is producing 500 tonnes per year and they’re projecting an increase to 700. Meanwhile, the last terrestrial producers have closed, except the ones that produce platinum as a side product of nickel refining. The price is still strong, but I don’t know how long it’ll hold up.”

“Gold production will be 600 tonnes this columbiad,” added Will. “So, Mike, what do you make of the situation on Mercury? Have you heard anything?”

“I exchanged some videomails this afternoon with Gerhard Frick, who’s in charge of the PGM production effort. The difficulty of their plans is beginning to sink in. The roadway needs to be upgraded substantially and that isn’t as easy as they expected, with their equipment. The ataxite body is 120 kilometers from Concord, so they have to install a high-voltage power line from Concord to the site and it needs special protection from the sunlight and special grounding, because solar storms produce particularly powerful electrical surges at the Mercurian poles. The excavation area requires special sun shields; nickel steel sheets that are 1/10th holes to reduce the sunlight passing through to a reasonable level. They also need special lights for the nightspan unless they can station a solar sailer in orbit to reflect light down onto the excavation area. They are also installing buried housing and work areas; some of that was moved from Caloris Station. The moon has all of these things, but the moon can get them much more easily than Mercury can! Mercury still has limited personnel, too.”

“They’re also dealing with new uncertainty about support,” said Will.

“Yes, I heard about that, too. Yestersol the galleon and caravels left Earth for Mars via Mercury bearing forty extra residents for Concord and two hours later the Europeans immediately announce they want to cut the expansion back from 200 to 150! Everyone’s furious. The additional expansion isn’t very expensive! The Belgians are committing to send a caravel to the asteroid belt and it’ll cost almost as much as the fifty personnel being cut from Mercury!”

“I think the Europeans will keep their commitment, though, and it isn’t clear the Belgians will send that caravel; the government is the laughing stock of Europe and of half its population for making the proposal,” said Will. “The fifty additional people on Mercury will only cost fifty million redbacks per year, which is nothing for Europe. But the economic recovery is so slow and costing so much, every penny is scrutinized.”

“I suspect Mars will have to make a commitment to Mercury, too,” said Ethel.

“But should they pursue borough status?” said Will. “Because that’s what’ll happen. And if they do, Magellan Station will want to pursue it as well.”

“Maybe the thought that you’ll impose safety standards on them will scare them away!” said Ethel, with a laugh.

“I don’t know; the people I’ve talked to are grateful the government is staying on top of safety,” said Liz.

“Anyone who goes outside has ambiguous feelings about safety standards,” said Mike. “None of these environments are easy, and the equipment can never get good enough.”

“The Ceres people are excited about the new standards because they require an expansion of living space,” said Will. “An accountant would say that it raises costs, but the expansion will be covered by the government anyway. They have to be.”

Just then the doorbell rang. Ethel said “Come in” and a moment later the door opened. A robotic cart rolled in with supper: cheese and vegetable lasagna and salad. Mike jumped up and grabbed the two items, prompting a “thank you, have a good sol” from the cart, which turned around and headed for its next destination. He put them on the table and began to feed the twins while everyone else dished out food for themselves.

“I heard from Leo Cordova this sol,” said Liz. “He’s the professional basketball player who’s coming to run a three-month basketball camp this fall. They just passed Venus and he said it was awesome to watch them fall toward Venus, then head back out into space. Most of the tourists got into spacesuits and floated on the top of the galleon to watch it live.”

“That’d be the way to do it,” agreed Will. “He and the other tourists stay here four months, then return to Earth via Mercury; three planets in a year and a half! That’s got to be the ultimate tourist experience!”

“I’d love to see Venus some time,” said Mike. “Maybe some day, now that we’ll be running passenger flights past it to Earth at every launch opportunity. But I did hear from Exploration Corps this morning: I’ll be on the expedition to Gradivus next summer.”

“Congratulations!” said Ethel. “I’m proud of you, Mike. Don’t worry, we’ll help Liz with the twins.”

“He’ll be away four months,” said Liz. “I wish he weren’t going, but it’s his job.”

“We’re waiting until the twins are four, and I won’t be going away that long or that far again for some time,” said Mike. “I have a lot of research to do at Martech.”

“I have an announcement, too,” said Ethel. “I’m retiring as of December 31.”

“Really!” said Liz, surprised. “Wow!”

“The Board of Directors meets next week; I emailed them this morning and told them they needed to choose a new chief executive officer. Mars Metals needs young, vigorous leadership. PGM prices are volatile, and that makes the job exhausting. I’ll be seventy; that’s plenty.”

“I could use your help with the Bahá’í work anyway,” said Molly. “One retiree can greatly increase the Bahá’í community’s available human resources. Did you know the two galleons and the caravels on their way here are carrying 2,200 immigrants, and 102 of them are Bahá’ís? Five percent! Another 83 people have checked two religion boxes, like ‘Bahá’í’ and ‘Christian’ or ‘agnostic’ and ‘Bahá’í.’ I was amazed when I got the data. Apparently the screening questions favored people with multinational experience, people who spoke more than one language, people with multiple ethnic backgrounds, on the theory they’d fit into Marsian society better and strengthen its diversity.”

“That’s the Bahá’ís,” agreed Liz. “But most of these people won’t show up at meetings much.”

“Not until they settle down and have kids,” agreed Molly. “That’s the problem; the arrivals work crazy hours the first year or 18 months. That’s why we need retirees, to visit with them, encourage them, etc.”

“We should invite them all to the house,” said Will.

“And when will you have time to do that?” asked Ethel.

He nodded. “Next year, I think we’ll both have time to do it.”

“I hope so!” she replied.

Arrivals and Departures

August-September 2073

Father Greg paused a moment before ringing Will Elliott's doorbell, but decided he should. He pressed the button.

"Hi Father Greg! Come on in!" exclaimed Ethel a second later.

"Thank you," he replied, assuming they'd hear him. Most likely, a wall screen in whatever room they were in had switched to the doorway camera and they had seen him immediately. The door clicked and he pulled it open, entered the house's main airlock, closed the door behind him, and a moment later opened the inner door.

It led straight into the house's great room, and seated on the couches and chairs was quite a crowd; Will, Ethel, Liz, Mike, Shayda, Jason, Molly Nuri, Paul and Jacaranda Nuri, Paul and Jacaranda's eleven year old twins Tracy and Samantha, George Tobin, and his wife Cecie. The remnants of Chinese food boxes were scattered about on tv trays. "I see you really don't need my pastoral care, Will!" exclaimed Greg.

Will laughed. "Thank you, but I suppose not. The extended family has rallied around me."

"Have some coffee, Greg," said Ethel, pointing to the coffee pot nearby. That prompted Mike to jump up and pour a cup for the priest.

"Thanks." Greg looked around for a seat and Will moved over, so Greg sat down next to him. "It looks like you've recovered alright."

“Well, a good meal and a lot of love helps.” Will sighed. “Cancer is always a very frightening thing, no matter what the medical technology is.”

“What’s the prognosis?”

“Tatiana’s not sure yet. They spotted it on a routine body scan a week ago and did a second, more detailed scan two sols later. It was only a millimeter across; very tiny. Barely the size of a big salt grain. So Tatiana went in today and took it out.”

“Microbot?”

“Yes. She put me to sleep, inserted a needle into my pancreas with the microbot, it pulled out the mass and zapped the area with a laser, and she pulled the microbot out fifteen minutes later. I have a tiny puncture in my side 2 millimeters across; it doesn’t even need a band-aid. I also have a slight, vague ache inside me from the small burned area. The anesthetic was the worst part; it made me feel a bit nauseous for half an hour.”

“Chemotherapy?”

Will shrugged. “They’ll analyze the DNA of the cancer and determine what its vulnerabilities are. If they spot anything on the scan next month, Tatiana may hit it with a microbot again, or they’ll concoct a cocktail designed to kill it.”

“Catching something that early is usually pretty effective, and the chemotherapies nowadays are incredible.”

“That’s what Tatiana said; 99% survival. A century ago, this cancer had a 95% death rate. Statistically, pancreatic cancer seems to be a bit less common here than on Earth, so it probably has no connection to radiation or dust.”

“Probably other environmental factors that don’t apply here, like pesticide residues.” Greg looked at him. “But it’s a trial, isn’t it?”

“Yes, it really is, even if the procedure is incredibly quick and there’s almost no recovery. Hey, it’s your body! That’s pretty personal.”

“And it’s a reminder of mortality.”

“Yes, exactly, as was the loss of Roger a few months ago. Most likely, we’ll live longer here than on Earth; we have no tobacco smoking, virtually no alcoholism, very little obesity, and the best medical care of any population in history. But we’re in this world for only so long anyway.”

“Yes, we have a time to get something done, and then we move on,” agreed Greg, not wanting to push theology much. “I’m so glad to see you have so many people with you, your family is a true blessing.”

“Even Marshall and Amy called,” added Ethel.

“Do you have to slow down your duties at all?” asked Greg.

“I’ll get a good night’s sleep tonight and then we’ll see. I probably will need to rest a bit more for the next few sols. I’m not as young as I used to be!” Will paused. “It’s just about time for me to retire, Greg.”

“You still have a few months left to this term, Will.”

“I do. People have adjusted to the new safety guidelines, so that development has been successful. The galleon *Vega* is filling up and will leave Earth for Mars next month, and the galleon *Castor* is ready to receive its passengers. The two Prometheus shuttles have been broken in and are working well, so we have the launch capacity we need; one will even be on its way here in December. The *Bellatrix* will be here in November via Venus with a fleet of caravels, and the *Alcor* has passed Mercury and is on its way for an

arrival in late February. We're ready for four thousand arrivals. We have a borough on Ceres and a solar system exploration plan. So it's been a pretty good term, I think."

"I think so, Will," agreed Greg.

"Definitely," agreed Mike, and everyone nodded.

The doorbell rang. "It'll be Sam, Mindy, and Madhu," said Mike, and the screen flashed alive with their faces a moment later. "Come in!" Ethel exclaimed.

The door opened and the three adults entered with Victor, who saw Jason and hurried over to his friend. "Welcome, welcome!" said Will, rising to greet them.

"No, no, sit, you just had surgery!" said Madhu.

"Surgery? You want to see the puncture? You really can't see it!"

"Nevertheless, it is surgery," said Madhu. "I've had them and I know!"

"That's true, you know." Will embraced her. "Thanks for coming."

"Have coffee and tea. Oh, I think we need more," said Ethel.

"I'll get it," said Liz, and Mike jumped up to help her. They pointed to their seats so the arrivals would have a place to sit. Sam followed them across the garden and grabbed two chairs over by the kitchen.

"So, you plan to survive?" asked Madhu.

"Yes, and the doctors anticipate that result as well. I need to lose three kilos over six months, though, and exercise a bit more. I can do that."

"Good. I'm afraid I have involuntarily lost eight kilos over the last six months, but my weight is going back up, now."

"You've had big adjustment," said Ethel. "Starting in January, once I retire, we'll can do more together."

“That’d be great,” said Madhu. “I’m back to work on the landscaping design around the high school, and I have some art projects I’m starting. So things are getting better, I guess.”

“I think you’ll both be so busy, you won’t have time for bridge, or leisure activities like that!” said Mindy.

“We’ve got grandkids to raise, too,” said Ethel.

Sam returned with the chair and sat. Will turned to him. “So, you’re back from the Thaumasian Uplift.”

“Yes, we got back yestersol after five weeks of exploring the ‘Oberland’ uplift at the chain’s northeast end, which is its most promising section. It’s pretty spectacular; it rises five kilometers in about fifty kilometers and it’s cut by fossae and craters in several spots, so there are some impressive cliffs. It has the best pegmatite mineralization on Mars, as you’d expect of something resembling a terrestrial island arc! Not only is there plenty of spodumene for lithium; we found small but minable deposits of beryllium, aluminum, tungsten, tin, molybdenum, fluorine, and niobium, plus gem stones such as garnet, beryl, tourmaline, and topaz.”

“We’re importing a hundred tonnes of aluminum from Earth this columbiad because Tithonium hasn’t been able to refine enough, so this is welcome. Even the gemstones are a nice addition!”

“There’s good quality building stone, too; really pretty granitic outcrops. We’re shifting our recommended building site for a projected outpost to Apgar Crater. It’s a little 3-kilometer crater that breaches the rim of Grandi and provides a natural route up into Oberland. It has good ground water resources. The floor of Grandi is below datum,

so passenger and cargo flights are convenient, and we already have a decent thousand-kilometer trail to it from the Uzboi Highway. From Apgar, most of the ore bodies are less than one hundred kilometers away, so a single outpost can support a lot of diverse mining efforts.”

“Would we need mining oases?”

Sam nodded. “There are a few ore bodies that are withing ten kilometers of each other, so one quonset with life support and a garage, and associated solar arrays could support at least two mines. We need to start with five oases, though most of the mining will be robotic anyway. The outpost would host remote control and refining facilities. They need a lot of water and power, so they have to be at Apgar.”

“What’s the altitude of the floor of Apgar?”

“Seven hundred meters above datum, so it’s too high for an airport, but the Grandi airfield would be only thirty kilometers away and more than a kilometer lower.”

“That’s a good plan.” Will nodded. “I’ve been following your dispatches to Emily Scoville-Rahmani closely; I asked her to forward them to me, and we talked about them last week. The Thaumasia plan is well developed and we think it’s time to move to Phase 1, where we send a construction and mining team there to set up an initial outpost and tackle mining of the first priority minerals. We’d send forty workers, I think. Is the access road class 1 or class 2?”

“Class 2, except for two short stretches.”

“We’ll need to upgrade the stretches, then, so we can get six by six meter Quonsets through.”

“Are you actually going to move forward with this outpost? Because you just approved an outpost at Alba Patera.”

“The mining companies are paying for that one because they want to go after the gold deposits. Yes, I think we should start two new outposts. One maintains our gold income and the other diversifies our raw material supplies. How would you like to command the Thaumasia setup?”

“Me? Sure!”

“You’re the logical choice. You’ve explored the Oberland Uplift three times and commanded the last two efforts. You’ve coordinated the planning and contributed centrally to the thinking. Many details are yours and others have agreed with them; if they haven’t, you modified your suggestions and supported the consensus. You’re an excellent field geologist, which is essential for this task. You don’t know how to command a construction effort, but we’ll appoint a construction supervisor to work under you. There will also be an ore refinement director and an environmental control officer, when the outpost grows large enough, and the commander will be replaced by an elected mayor after six months or a year. Do you want the job?”

Sam looked at Mindy and Madhu; he had responsibilities with them as well.

“Can Victor go along?” asked Mindy.

“After a few months, yes,” replied Sam. “We’ll have to get the Quonsets set up and buried first, and get a B-75 agricultural bubble set up.”

“Two B-75s, based on the new guidelines,” said Will. “Unless we define it as a ‘temporary oasis’ at first.”

“With your geology and engineering experience, there would be plenty for you to do,” said Sam.

“More than here,” agreed Mindy.

“I can manage without the two of you,” said Madhu. “I’m getting an amanuensis robot, after all, to help with cooking, house keeping, and secretarial duties. I can even come to Thaumasia sometimes and help with the art and cultural efforts there!”

“I think you would be the art and cultural efforts there,” replied Sam, and they laughed. He turned to Will. “Okay, I’ll do it.”

“Good. Let’s get together in a few sols to plan Phase 1.”

It took a long time for the *Cassini* and its accompanying caravel, the *Beagle*, to cross the Saturn system. Even at twenty kilometers per second, 72,000 per hour, 1.7 million kilometers per day, it took over two weeks to go from the orbit of Fornjot, slowly rolling around Saturn at a distance of 24 million kilometers, to Titan, which was moving exactly away from the *Cassini* the day it arrived. As the *Cassini* closed, the cargo module riding on its back detached and prepared for its own encounter with the solar system’s largest lunar atmosphere. Galleon, caravel, and cargo module each arrived an hour apart and burned off their speed against the fluffy envelope of nitrogen and methane molecules.

The *Cassini* was first. Except for the personnel in the bridge, no one at Acheron was doing their daily duties; they were anxiously glued to their screens, watching the altitude and velocity charts and a poor quality video from the cargo module. Most gathered in the great room in N-4 so they could experience the arrival together. For twenty minutes the *Cassini* shot through the atmosphere in a blaze of entry, riding the air

to keep the deceleration constant and controlled. Speed burned off, it settled toward the surface for an hour, occasionally firing its jets for steering. A final blast of the engines removed the last hundred kilometers per hour of velocity and brought the *Cassini* down in the center of its landing pad a hundred meters from the *Von Braun* and *Korolev*. Loud applause broke out in the great hall in N-4.

“Safe and sound!” exclaimed Guangya.

He and Marshall slapped hands. “That’s half our new arrivals,” added Marshall.

“Some new faces to see for the first time in five years!” added Amy.

“A new cellist, a new pianist, a rather funny comedian, a video maker, a painter, a potter, a quilter . . . all sorts of artistic talents!” said Ryoko, who was very pleased by the non-professional capacities of the new residents.

“*Cassini* crew is cleared for egress,” exclaimed Yuri over the public address system.

‘Let’s go greet them,’ suggested Gandhimohan. The entire crowd in the great hall rose and headed for the outpost’s main tunnel, which was eight meters wide, with six bubbles on the north side and six on the south side. They followed the tunnel westward three hundred meters to where it ended. Three smaller tunnels ramped upward from there; straight ahead to the *Korolev*; to the right and northward to the *Von Braun*; and now to the left and southward to the *Cassini*.

It was a long, chilly wait, for the plastic tunnel sides conducted the soft cryogenic cold of Titan’s ice crust to the passageway, which was little heated. But finally they heard footsteps. Andries Underwood, commander of the *Cassini*, led the way. As soon as he appeared, everyone broke out in applause and cheers. They pressed against the sides of

the tunnel so the sixty arrivals could pass between them. Everyone was hugging and shaking hands in greeting; some residents, in their excitement, accidentally hugged each other. Willie, who was in Amy's arms, was very excited and kept repeating "Welcome! Welcome!" over and over.

When Andries got down to Marshall, he didn't recognize him for a moment. "Marshall, I haven't seen you in years!" he gave him a very warm hug.

"Welcome to Titan, Andries! It's good to see you again! Seeing you again brings back memories from childhood!"

"Yes, when I first arrived on Mars in '42, you were a toddler!"

"I was two. And here's my son, Willie, who's a month short of his fourth birthday."

"Named for your father. Well, hello Will Elliott." He took Willie in his arms and kissed the boy, who was surprisingly cooperative. "My goodness, kids are so light in this gravity!"

"Yes, it makes it hard to stop carrying them!"

He handed Willie to Marshall. "Say, where's the big park area, and where's the lake? We're desperate to see both, after 18 months in space!"

"The park area is N-7; first door on the left. They've been extending it and pretty soon the first rear addition will be open. The lake is S-3; fourth door on the right."

"Thanks. I'm looking forward to working with you, Marshall." Andries continued forward to be greeted by the others, many of whom knew him, for he had been among the first fifty to arrive on Mars and stay. He gave Amy a kiss.

They continued shaking hands and hugging until all sixty had passed. “I’m surprised; I don’t know more than half of them,” said Marshall. “Mars has gotten so big.”

“Of course, some arrived straight from Earth; not all of them had been on Mars before.”

“True, but even some of the Earthers had been on Mars previously. This place is going to be crowded for a month, until the *Beagle* heads back to Mars.”

“But we’re all so excited to see new people.”

“It is nice; we were becoming an insular little village! Let’s go find Andries, I’d like to say hello to him more.”

Amy nodded and they headed for N-7. Over a year ago they had held a dinner in a tent in the newly carved cavern, which had been thirty-seven meters wide and eighty meters long. Since then, they had made the cavern seventy meters longer and had installed an arched, insulated nickel-steel roof and floor. The latter was covered by artificial soil, which was grassed in the middle and had a line of trees growing along the edges. It was by far their largest completed space, though the door was open to the rear cavern so everyone could see it, and it would be twice as wide and high..

They walked the length of N-7 and looked into B-1, their first bioarchive cavern. Andries wasn’t in either, so they walked back out and entered S-3. Titanus Lacus was finished and the wave generator was turned on, so the lake’s surface and the reeds along the edge were undulating. One arrival had jumped in, clothes and all, and everyone was watching and laughing. Another, shorn of his shirt, was sitting on the lake’s little island, relaxing and dripping. Others were wading along the sandy beach or pointed at the fish. Andries was sitting on a rock watching and smiling.

“It’s beautiful in here, isn’t it?” said Marshall.

“Oh, it’s heavenly! The galleon’s courts are nice, but this is fantastic.”

“Titan’s going to be the best place to live in the solar system.”

Andries was startled by that. “Why do you venture that opinion?”

“Well, we can go outside, just like on Mars. It’s more difficult, and we have to be more careful, but we can do it. Pretty soon we will have some big caverns; I suspect in a decade or two they may reach a hundred meters width and height, and of course the length can be infinite. I think our spaces won’t be that much more expensive than Mars’s, too; we have to add light and heat, but we don’t have to pressurize them. We now have bioarchive as well—”

“Who would have thought of that?” added Andries. “When bioarchive was first proposed on Mars, we all thought it was a waste of money. But of course we don’t have an open sky here, like on Mars.”

“True, but look up at the metal dome, painted with white cumulus clouds and a blue sky between. They’re far enough up so you really can’t tell where they are. It looks like a bright, mostly overcast day on Earth.”

Andries looked up. “Well, close. And there are no stars to see at night!”

“I wish we could project a three dimensional image of Saturn onto the sky, like in a planetarium,” agreed Marshall. “Maybe that’ll be possible. The other thing we have here is zero radiation; even less than on Earth. And zero ultra-violet.”

“True; it’s better for Willie to be here than on Mars, that way. We also have a huge planet and several dozen moons to explore by remote control or quick expedition; Mars doesn’t have that. But you don’t have the family here that you have on Mars.”

“I miss dad, mom, and my sister, too,” agreed Marshall. “But my parent’s generation left their parents behind on Earth, and I’m grateful for that.”

“That’s true, and there’s quite a community here,” said Andries. “And you also have quite a gravity range; everything from 0.75 gee to 0.14. But you may want to send your boast to Helmut Langlais. I suspect Ceres will have the big caverns and the population soon enough, too, because it has an economic base that Titan lacks.”

“We do have a little ataxite! I admit, not enough to make money on, and Titan’s thick atmosphere makes it hard for space vehicles to attain space; though it is easier than from the surface of Mars. We certainly have more worlds to explore than Ceres.”

“I don’t know about that. I bet several hundred asteroids pass closer to Ceres than Fornjot does to Titan. And they are making plans to send probes to all of them.”

“Hum.” Marshall considered Andries’s arguments. “I agree; Ceres has advantages, if they seize them. But right now we have four times more population. If we can build our unity and community, if we are creative in attracting grants for our research, we can thrive here.”

Andries nodded. “On that, we all agree. I’m looking forward to my stay here.”

“How long?”

“At least five years. I’m 58; I’m sure I won’t stay more than ten years.”

Marshall pointed to Willie. “We’re here for at least fourteen years, I think.”

“That’s more or less what your dad said,” replied Andries, and Marshall laughed.

“It’s been so long,” said Charlie Langlais as he stepped into Andalus Square with Uncle Kristoff. He stopped to look up at the soaring dome eighty meters overhead.

“If you think this is high, you have to see the new enclosures,” replied Kristoff.

“I don’t remember the blue sky and clouds.” Charlie pointed up.

“I don’t think it was there when you left seven years ago. They replaced the nighttime insulation blanket three years ago and when they did, they added the ‘sky filter’ as they call it. It looks great when the sky outside is clear, but I’m afraid it looks awful during duststorm season!”

“Yes, a blue and white filter on a cinnamon colored sky; that’d be weird.”

“Exactly.”

“Did I tell you it looks like I’ll have a dorm room at Martech, starting next week?”

“Yes, you mentioned it. The longer you can stay with dad, the better. Frankly, Charlie, he’s 81, and even though he’s still in good health, we’d rather have someone with him. Even for a week; none of us are really sure how he’s doing, even if he lives next to us.”

“Does he keep the place neat?”

“Spotless, but that’s because he’s told the house cleaning robot where absolutely everything goes and how to clean everything exactly. A human house cleaner would go crazy. The robot takes twice as long to clean his place as average, the cleaning company has told me, and he has it come three times a week.”

“That’s grandpa; that’s how he has always been.”

“Yes, but he seems a bit more forgetful now. Never mind, you’ll see.”

“Uncle Kristoff, I can stay with him a week or so, but I really want my own dorm room. I’m grown up now, a man, and I need my space.”

“Sounds like you need something else.”

“Well, I suppose I do! There weren’t any women anywhere near my age at Central.”

“I’m sure, and I know how you feel; I was there too, one time. I even had the same argument with dad. Okay, I’ll back you up. There still aren’t that many women who are nineteen or twenty here, though. In a few years you’ll be the same age as the arrivals and things will change.”

“True, but I was here until sixth grade, remember, and I went through high school via distance learning with all my friends! My graduating class had eight kids. Some of us are getting together tomorrow, like Wicahpi-Luta Hunter and Guillermo DelRio, and Sirikit Thanarat and Esther Harris.”

“Daughters of a Bahá’í Auxiliary Board member and a Catholic priest; good luck with them!” Kristoff laughed.

That irritated Charlie. “I’ve already completed my entire Freshman year and half my Sophomore year, between advanced placement and the field geology credits from my work on Lutetia, so I’m a sophomore, just like them. Because the undergraduate component is so small, we get really good attention from the teachers. I’m really excited about it.”

“College is a great time.”

“And it’s so good to be back on Mars! Ceres was okay, but it’s Hicksville; nothing happening. It’s ridiculously tiny. Nine kids, and I was three years older than any of the others. Oskar had it much easier; his best friend is a year younger, and there’s a girl a year older with whom they study.”

“He’s nine years younger than you. I bet his grade has 150 kids in Aurorae Middle School. You’ve got to walk as far west as you can and see the really big new spaces. There’s even a ski slope in South Baltic, though the snow is melted now.”

“I want to see your Ukraine.”

Kristoff smiled. “And it’s all mine, now. Believe it or not, I own ten percent of Aurorae Outpost!”

They entered the tunnel to Cathay Enclosure. They had to slow and move to the right when a cart bearing a family and groceries wanted to pass them at the same time a cart with passengers was going in the other direction. Kristoff pointed out the lines on the floor “the outer lanes are for pedestrians.”

“I’ll remember that. Oh.” He saw a family was coming toward them in the sidewalk area with a robot pushing their baby carriage, so he stopped and pushed against the wall. They nodded to both men; Kristoff knew them. “There’s traffic and robots now!”

“Yes, things have changed a lot in the last two years. Before the war, it was too expensive to import robots or carts for personal use, and labor costs here were too high to make them cheaply enough. I know; I wanted spiderbots for harvesting and couldn’t get them. The government has been kicking itself for not importing a lot more robots before the war; it would have made life much easier during the cutoff. But since the war ended, they’ve imported a lot and greatly expanded robotic manufacturing, so you can now buy carts and robots at a reasonable price. Most people still use robotic taxi carts rather than owning a cart, and most subscribe to various robotic services, like cleaning or cooking. Families are getting family care bots, though.”

“The Martech catalog says students can’t take robots to class with them, because they can video record the entire class.”

“Yes; a lot of professors have copyright concerns. I’m a lot more worried about the situation on Earth because the factories are laying off millions of workers and automating. The cost of consumer goods has fallen by a half or more, but the workers have to buy them with unemployment checks and they’re very discontent.”

“Yes, the tensions are tearing apart everything.”

They exited the tunnel, crossed Cathy, passed through another tunnel, then walked across Punjab Enclosure. Half way down the tunnel beyond, they turned right and entered an underground development. After crossing four bubbles—each with a sunny central courtyard—they passed through a B-75 bubble with a big central area of clover and coffee trees lining the edges. “Mine,” said Kristoff. “It’s a public park but I’ve leased it.” They continued into the next bubble and when they reached the first garden they turned in. The living room was open to the garden and filled with family.

“He’s here!” said Sebastian, jumping up. His hair was thin and totally white and he was thin as well, but still spry. Charlie headed straight to his grandfather.

“Hi, grandpa.” They hugged and kissed. He turned to Aunt Irma next and kissed her, then to the twins, Mark and Nicola. “Hey, you guys are so big! Sorry I missed your birthday!” They had turned thirteen just a few sols earlier.

“We wish you had brought Oskar!”

“You all had so much fun with him.” Charlie turned to his big bag, opened it, and pulled out presents. “Better late than never, huh?”

“How did you do that?” asked Mark.

“I shopped at the Silvio’s on Lutetia.”

“Yeah, right, no one lives there!”

“No, really, I stopped at the Silvio’s on Phobos. We had to wait three sols for a flight down.” He turned to Kristoff. “I bet you wouldn’t recognize the place.”

“Oh, it’s amazing. We have three times more people doing manufacturing on Phobos than all of low Earth orbit! And I don’t know how many B-75s they have now.”

“More than fifty, enough to feed everyone on Phobos and the moon, plus supply the fancy tourist restaurants in low Earth orbit. I was talking to some people there about opportunities; it reminds me of Ceres, and I want to continue my zero-gee hockey.”

“Well, please stay here for a year or two, at least!” said Sebastian. “I want to get to know my oldest grandson better. My, you grew up to be a handsome, strong man! I’m so glad.”

“All that childhood radiation exposure didn’t do him any harm, fortunately,” added Irma, who had never approved of Clara’s casual attitude toward threats to Charlie’s health.

“So, far, anyway. I’m looking forward to spending a lot of time with you, too, grandpa. I was reading your memoir on the flight here. It was in mechanical translation from German, but that was good enough.”

“They’re coming out with a real English translation next year. I just finished recording about 200 hours of personal recollections of my career, too, so I’ll make some changes first. That took most of my free time for the last year!”

“Do you ever get outside?”

“Not on expeditions; no, I haven’t done any of those for six years. But I try to play golf every week if I can find a partner.”

“You can go out with him and relieve me of the duty sometimes,” added Kristoff. “They finally finished the eighteenth hole last year.”

“It’s something you can’t play on Ceres; a 3-wood would send a ball five kilometers! I’ll be glad to teach you. You’ll meet interesting people, too, since I mostly play with old geezers; you know, the people who founded this place?”

“That does sound interesting.”

Sebastian pointed. “That’s your bag? If you want, we can take to my place; it’s right across the garden.”

“I can wait; besides, I’m hungry after the long flight.”

“You would be. I’m looking forward to having you around.”

“Thanks, grandpa, I’m looking forward to it, too. But I do have a room in the dorm, starting next week.”

“You do? It’d be much cheaper to stay here, and I’d really like it.”

“Dad,” said Kristoff. “It’s okay. He’ll be around plenty. Let him enjoy college life.”

Sebastian looked at Kristoff a moment, then nodded. “Fair enough. Indulge me for a week at least, though!”

“I’ll be glad to, grandpa. You can help show me around.”

“No, Mark wants to do that!”

“I really do, Charlie! I know every enclosure!”

“Great, I look forward to that, too. Can you go outside yet? Because there are some trails I remember a bit from when I was thirteen; dad let me go out with him a few times.”

“He’s not certified yet; a few more months,” replied Irma. “Nicola wants to get certified, too.”

“Good. You two show me around inside and I’ll show both of you around outside, how’s that?”

Mark and Nicola smiled at once. ‘That’d be great!’ they both said.

21.

Censure

Early October 2073

“Lunch! What a surprise!” Anne Hollingworth looked at her son, and the tray of food in his hands. with surprise

“Well, mom, I’m departing for Phobos tomorrow morning and I wasn’t sure I’d have any time to eat dinner with you and dad tonight,” replied Bill. “I asked dad to come along and he may show up yet, but he had a big meeting.”

“The work on Saturn 3 is peaking right now. So, you’ll be back Frisol?”

“Yes, it’s the standard passenger flight; half a sol up, two sols there, half a sol back down. I’m copilot again.”

“Fantastic! Twenty-three years old, Mars’s own home-grown pilot!”

“Well, I’m not pilot yet, and there’s not much to do! The vehicles fly themselves.”

“But you have to be ready in case of emergency, and that means constant training and acquisition of experience. This is not like an elevator operator!”

“No, nothing like that; did they really have elevator operators?”

“I guess, generations before I was born. So what did you get?”

“They had a really good vegetable soup at Deseret, and I got you a vegemite sandwich.”

“They had vegemite this sol! God bless you.”

“It’s not as good as the stuff from back home.”

“Good enough, though.” She took the soup and sandwich. Bill pulled a chair around and took over a corner of her desk. He had a turkey and cheese sandwich for himself, and had brought two cups of coffee. “I have an appointment in fifteen minutes—no, ten, now,” she added. “So we have to eat fast.”

“I’ve got to get to the university for my Monsol afternoon seminar on advanced propulsion systems anyway.”

“When’s your presentation on high pressure engines?”

“Three weeks; plenty of time to finish work, in spite of the flight schedule. Next semester I’m signing up for the month-long intensive on solid core nuclear engine maintenance on Phobos.”

“Oh? A perfect course for Saturn 3!”

“I know, but I’m not putting in my name, mom. Maybe Saturn 4. I know dad wants me to fly out with you; you guys have told me many times.”

“You’re certainly qualified, and it’d be nice to keep the family together.”

“I know, it’s just that I want to avoid the appearance of favoritism. I’ve got to give Sheila a chance—”

“The two of you have broken up.”

“Well, maybe.”

“Sounded like it to me. But never mind; it’s your life, you’re an adult now. You need your time.”

“I really do, mom. Give me a few years here on my own, in my environment. Of course, if I get married, who knows where she’ll want to go; maybe nowhere. But we’ll see.”

“I know. And Bill—well, we’re incredibly proud of you.”

“Thanks, mom.” Bill seemed embarrassed by that. He looked around the Mayor’s office. It wasn’t easy being the only child of the Mayor of Aurorae and the former Commissioner of the Asteroid Beld Commission. It wasn’t easy being the offspring of the first generation, period.

They ate their lunch in silence for a minute, then there was a knock on the door.

“Oh, Ramesh! Come in. Have you met my son?”

“I think so; Bill, right?”

“Yes. Good to see you again, Ramesh.” Bill rose and shook his hand. “I brought my mother some lunch, but we’re done, so I’ll be going, now. I’ll try to stop by at your house about 9 or 10, mom. I’m having dinner with some friends.”

“Okay, dear. See you then. Try to stop by tonight even if it’s late, or call tomorrow before launch, okay?”

“Okay, I will. Bye.” Bill hurried out.

Ramesh sat. “Launch? Where’s he going?”

“Phobos; he’s the copilot of the weekly passenger flight morrowsol.”

“Copilot? Wow, and he’s in his early twenties?”

“Yes, twenty-three. We’re very proud.”

“He must have a nack. And he has a Master’s?”

“He got it back in June, in engineering. We’re hoping he’ll come to Saturn with us, but so far he wants to stay here for a few years and be on his own.” She shrugged.

“When are you resigning as mayor? Next month?”

“No, I’ve told people I’d continue until April. That’s three months before launch, and I don’t need any special training for the flight. Of course, who knows whether I’ll be reelected to the Mars Council or the City Council in two weeks.”

“Why not? You’ve done a good job. The voters don’t throw people out because they’re scheduled to leave in a few months.”

“That’s true. I’m expecting six more months. That’s why I thought we should talk about reviewing the city planning document with an eye for updating it.”

“When we drew it up, Aurorae had 2,000,” noted Ramesh. “It was a plan for expansion to 50,000 and it seemed like we’d never get there. But we’re growing pretty fast now and we may get there pretty soon.”

“I was talking to Yevgeny and Alexandra at lunch yesterday and we hit on a rough formula that seems pretty good: assume each immigration wave is fifty percent bigger than the previous one, and that Aurorae gets half the migrants,” said Anne. “That assumption sounds high, but the immigrants generally start families two or three years after arrival, so these assumptions include that factor to some extent. We have 4,000 arriving in the next seven months and Aurorae should grow by 2,000, between immigrants and workers moving here with their families from other outposts. Mars will grow to about 15,000, Aurorae to about 10,000. In 2076, add 6,000 and 3,000; Mars goes to 21,000 and Aurorae to 13,000; 2078: add 9,000 and 4,500; Mars goes to 30,000 and Aurorae to 17,500. Projected forward, Aurorae grows to 24,000 in 2080, 35,000 in 2082, and 50,000 in 2084. Just ten years.”

“But will the growth continue?”

“Who knows? The prices of PGMs, gold, and deuterium are holding up pretty well and immigration on that scale will push the ticket price down quite a bit more, maybe to 100,000 redbacks per person. At that level, immigrants can afford to borrow money to finance their own transport here. They will do so if we are still a land of promise and potential, and I am sure we want to maintain that.”

“So, should I make a plan for 100,000?” asked Ramesh “At the rate you’re talking about, we’d hit 100,000 by 2088!”

“That’s the least we should do. We may even want a rough outline for 250,000. The spaceport is moving farther south, so we can start the development axis you’ve proposed on the south side of Boat Rock and Layercake Mesa.”

He smiled. “Good. We’ll need to shift agriculture to new domes to the north and convert the existing enclosures into urban areas. That will keep the development along the existing transportation axis. But that will work only until the population grows to thirty thousand, maybe fifty thousand. Beyond that, we’ll need a new transportation axis to the south of Boat Rock and Layercake Mesa with a much higher capacity; four tunnels of two or three lanes each, possibly with connector tunnels northward to our current system. We may want to reserve a future transportation corridor to the north of our existing development, too. Andalus is getting crowded and is over capacity, so Aurorae will need a new downtown. I’d move it west to one of the new large enclosures, so there’s plenty of room. That would also have the advantage of converting our existing transportant system into a feeder to a new hub. It’s hard to thread new tunnels under existing enclosures.”

“We’re going to need a new scheme for naming domes, too,” she said. “Aurorae already has 41 domes!”

“Eventually we can put one big dome over many of the existing ones and remove them; that will help. I don’t know whether Pacific will be 1250 meters wide by 2,000 meters long; that’s the current projection. But if it isn’t that big, some other dome will be. An enclosure of that scale can house and feed almost 20,000 people. The domes will probably get bigger, too. So an Aurorae with 250,000 people may only have twenty more domes.”

“That’s amazing. When can you have the updated plan?”

“There are a lot of changes to make simply because a lot of the assumptions from five years ago don’t apply any more. But I can do it by the end of the year.”

“December? Alright, that’s good. That gives four months before I’m finished for public input and finalizing a lot of the details. Great. The same fee scale?”

“Yes. This is a task for a team of eight, full time, and I know who I’ll ask. So I’ll get started right away. Now, can I ask you about another matter?”

“Sure; what?”

“Like you said, the elections are in two weeks, and I am extremely concerned about them. This is a pivotal election; we’re facing an immense growth in the next decade. We can’t do it with an octogenarian at the helm.”

“What? Ramesh this is not—”

“Anne, hear me out. Will Elliott has steered us well for several decades; that’s true. But it has been decades. We need new leadership, and especially younger leadership. Vision is good, but it has to be the right vision, and it has to be coupled with vigor. Lal

Shakaraman has been quietly leading the Mars Council for four years and is perfectly qualified for—”

“Ramesh!” exclaimed Anne, raising her voice. “This is totally unethical and inappropriate—”

“It is not inappropriate or unethical! Why do you say that? We *have* to talk about who will be our leader. It’s ridiculous sidestepping around it when the person has become the issue—”

“The person has not become the issue, that’s just your opinion. And this is inappropriate; it’s against the law, after all! And it is unethical. Maybe it isn’t in India or Australia, but look at the mess both of those places are in, with weak governments constantly undergoing change by razor-thin majorities, vicious political campaigns, permanent rancor and gridlock, severe partisanship, and continuous lawsuits and counter-suits between the parties. We don’t want to import that to Mars. Who would have thought that no electioneering and campaigning and a focus on everyone voting for people they think have experience and integrity would work, but it *does* work. It may not be perfect, but no system is.”

“But we can make it better, Anne, by discussing the qualifications of specific people.”

“And that discussion is going to be neutral and dispassionate? I’ll tell you how we can make the system better; we can report electioneering to the Supreme Court.”

Ramesh’s face turned red. “Don’t you dare do anything like that!”

“Why? Are you going to campaign against me, too?”

“No, certainly not! I just want this discussed, Anne.”

“Fine. You’ve discussed it. Now we’ve finished our business about the new urban plans. Have a good sol, Ramesh.”

“Alright, alright. Have a good sol, Anne.” Ramesh rose and walked out of the room.

She watched him go, still surprised. “Mingyu, did you hear that?” she called to her assistant in the outer office.

Mingyu stuck her head in. “He was electioneering against Will Elliott?”

“That’s right. I can’t believe it. The nerve.”

“He could get censured for that. He can’t get fined for that, can he?”

“For the second offense. For the first offense, you are banned from voting or being voted for. But he wasn’t electioneering for himself.”

“I think what he did was just as bad, though.”

“I agree.” Anne rose from behind her desk. “I think I’m going to ask Siddharth Swaminathan about this.”

“The Hindu priest?”

“Yes, I’m wondering what the religious and cultural dimension of this is.”

“Hum. I wonder if there’s any at all!”

“Well, I’ll let you know.” Anne Hollingworth headed out of her office. It was a short walk across Andalus Square and Cathay enclosure to Punjab, where the temple to Shiva, Prajapati, Ganesh, and Kartikeya was located. As soon as she entered, Siddharth, thinking it was a worshipper, came out. “Oh, good sol, Mayor Hollingworth! Welcome to our temple!”

“Thank you, Siddharth.” She glanced around and suddenly realized she was in a totally unfamiliar place, with an elephant-headed god on one wall and a multi-armed god on another. “Ah. . . I wanted to ask you a question.”

“Let’s go back to my office.”

“You have an office?”

“Well, I have to meet people somewhere. Follow me.” He led her past a curtain to a pleasant carpeted room with cushions on the floor for sitting, and, to her relief, a pair of comfortable chairs. He pointed to one; she sat in it and he sat in the other and waited.

“I wanted to ask your advice about something that involved one of your . . . members, before I jump on him. I don’t want to misunderstand, culturally.”

“Oh, I appreciate that. How can I assist?”

“It involves Ramesh Pradhan, who is normally very professional and full of excellent ideas about developing and expanding Aurorae. But a few minutes ago, after we discussed updating the city’s master plan, he urged me to vote for Lal rather than Will Elliott in the upcoming election of Chief Minister.”

“He did? I’m afraid there’s nothing cultural to misunderstand. That’s electioneering, pure and simple.”

“He seems to have a thing about Will Elliott.”

“He does. Some of it is jealousy; I think he yearns for the success and fame Elliott has achieved. And some of it is anger over the new safety guidelines, which require the larger domes to be subdivided until the outpost gets so big that none of them contain more than ten percent of Aurorae’s polder.”

“He did comment to me a few months ago that the new requirement was totally unreasonable. I found that puzzling, but I think he was enamored with the long sightlines in the big domes, and separate airtight compartments would disrupt that.”

“Exactly; he complained to me about that once as well. He has been campaigning for Lal; I heard him discuss it over lunch back in June. He insisted it was his right and that the anti-electioneering rules were an infringement of his rights. I warned him that it was indeed unethical and that Hinduism has plenty to say about the spreading of untruths about others.”

“So, that’s at least twice. What shall we do, Siddharth? Turn him in?”

“I think we should, Anne. You are the Mayor; I am a priest; we have to be spotless in our integrity. Either one of us could have misunderstood him, or he could question the honesty of either of us, but together he can’t.”

“And this must be stopped, or it will erode everything. Look at the terrible mess in Britain right now with the government see-sawing back and forth every few months because the voters are split down the middle.”

“And the demonstrations and counter-demonstrations that have turned into bloody riots in the United States. Societies are utterly polarized because politicians have discovered they can gain campaign contributions and power by converting minor issues into life-and-death ones. We can’t afford that up here.”

“We’re also too diverse; we can be pitted against each other.”

“Yes!” agreed Siddharth. “Lal wants an Indian to be the next Chief Minister. I’d love to see that, too, but not this way.”

Anne took a deep breath. “Alright, let’s go see Silvio DiPonte.”

Clara hurried into the Great Room of the *Piazza*, which was filled with forty people; more than half Central's total. "What did I miss?" she asked Helmut.

"Testimony by Anne Hollingworth, Siddharth Swaminathan, Rajan Yagneswaran, and Ichiro Otsu. Siddharth recounted a conversation with Ramesh and Lal Shakaraman about the importance of not reelecting Will Elliott and electing an Indian as Chief Minister, specifically Lal; the others recounted conversations where Ramesh specifically suggested they vote for Lal."

"What does Lal say about this?"

"He hasn't testified, but Siddharth said Lal was not encouraging Ramesh. The judges asked whether he discouraged Ramesh and Siddharth said 'no.'"

Clara watched Ichiro Otsu recounting his conversation of a month earlier. "I'm surprised they're broadcasting this live."

"Normally these are closed hearings, but Ramesh waived his right to privacy."

"Oh? Why?"

"I don't know."

Ichiro had finished his testimony. George Tobin, Ramesh's lawyer, asked a series of questions, probing for inconsistencies. Indira Kumar, the attorney general, asked a few questions as prosecutor. Silvio Diponte, Alexandra Lescov, and Ni Gao were the three-judge panel and all of them asked questions as well. Then Ichiro was dismissed.

"The defence calls Ramesh Prathan," announced George. All eyes turned to Ramesh, dressed in his best suit, as he walked to the front and sat. He took the oath to tell

the truth. “Ramesh, what’s your side of the story,” asked George. He sounded a bit nervous.

“My side of the story is quite simple. First of all, I have no problem with Will Elliott; people misunderstood my remarks, which may not have been phrased very clearly, and I apologize for that. My concern, first of all, is that a person can be in charge of Mars so long; he has held the highest position here, in one form or another, for thirty-four years. I don’t think that’s appropriate for anyone, even a Nobel Peace Prize winner. My second concern is that our political process has made this longevity possible. The ban on campaigning makes it possible for someone to remain in office ridiculously long. It infringes on our right to free speech and free expression, a very dangerous restriction that could lead us down a slippery slope to tyranny. The ban on campaigning is a throwback to an earlier era and does not reflect the modern political process. No nation on Earth would consider adopting such a system for electing its leaders. It is bizarre that we ban election campaigning. I feel strongly that it is my right to express my concerns and that a law preventing me to do so is unjust, improper, and must be overturned. The law, frankly, is unconstitutional and can be overturned on those grounds.”

George nodded. “So, did you exert your right of expression, your right of free speech, in your conversations with Siddharth, Anne, Lal, and Ichiro?”

“Most certainly. I expressed precisely the two concerns I have outlined above: that no one should be in charge thirty-four years, and no one should have their right to campaign for others restricted.”

“Do you feel that others should freely express their election preferences as well?”

“Absolutely. I hope everyone does it. We have to be free to speak about these very important matters; important to the functioning of our society, important to our own hearts. How can this freedom be restricted? How can it really be good for everyone in the longrun? We are mature adults! Perhaps moreso here on Mars than in any society in human history; we are all educated, trained to give our opinions, trained to work together, trained for patient give and take. Why can’t we express ourselves patiently, kindly, about how our society is run, and who will run it? Of course we can! That’s what I stand for; freedom to speak about politics and improve our society through our speech.” He ended with a note of triumph.

“Do you have anything further to say to the court about this case?”

“No, that’s my position.”

“Thank you. To you, Ms. Kumar.”

“Thank you.” Indira rose and walked to Ramesh. “When Mars held its first election in 2040, what was the position, and who was elected?”

Ramesh frowned by the request for history. “I’m not sure. The position was Chief Clerk of Aurorae.”

“Correct; today we usually call the position ‘Mayor.’ Érico Lopes was elected. Was Will Elliott on Mars at the time?”

“He would have been Commander.”

“Correct; a position that no doubt would have been enhanced and simplified if he had also been elected Chief Clerk. Then in 2049 Mars got a Governor; one appointed by the Commission, however, and Will Elliott was appointed. In 2051, Érico Lopes resigned as Clerk of Aurorae. Who was elected then?”

“I . . . don’t know, I wasn’t here then.”

“Ruhullah Islami was elected Clerk. Of course, later that year Will Elliott was chosen as Commissioner by the national representatives, and he served as Commissioner for three terms, until 2066. People felt there had to be a separate elected position, so in 2059 Mars got a Chief Minister, just as it has this sol. Who was elected?”

“I’m afraid that’s still ancient history for me.”

“Érico Lopes. He served three terms and then in 2064 he resigned because he felt there should be turnover. Then what happened? I believe you were a newly elected, up and coming member of the Mars Council?”

“I was there that sol. The Commissioner declined to nominate a replacement immediately, as he was legally obligated to do, and asked the Mars Council to give him a nonbinding recommendation. They voted for Alexandra Lescov, he nominated her, and she was elected Chief Minister.”

“Correct. A remarkable deference to the Marsian public, don’t you think, when the legal authority was his alone?”

“Perhaps it was remarkable, or perhaps it was a bid to boost his popularity.”

“What, he wasn’t popular? In 2066 when we achieved independence, who was elected Chief Minister?”

“Will Elliott.”

“How many terms has he served?”

“Two.”

“How many years has he been elected as a leader on Mars?”

“Almost eight.”

“Is that an example of excessive reelection of someone to office, or not?”

“Perhaps it is after twenty-six years of appointed leadership positions.”

“But the public had elected a Chief Minister already; Alexandra Lescov.” Indira pointed to her on the judge’s bench. “So, is this not election turnover of positions? She served a full two-year term.”

“Perhaps it is.”

“And while we’re talking about election turnover; you were elected to the Mars Council 2064; ten years ago. Have you served continuously on the Council since?”

“Ah, no, I was not reelected in 2068, but was reelected 2070.”

“I see; you didn’t resign from the Council, right?”

“No. I wasn’t reelected.”

“So, you know from your own experience that we have election turnover. Now, I also have a question about the issue of education and maturity. Were the good people at Concord Station, Mercury, as well educated and mature as Marsians when they held their first election in 2067?”

“I suppose they were. But why are we afraid of conflict? They had a tumultuous election and the commander had to resign. But was that so bad? That happens sometimes in governance.”

“Did I say we were afraid to conflict, Ramesh? I presume you would draw the line somewhere. Riots? Violence?”

“Of course, don’t be ridiculous!”

“What ridiculous about that? Riots and violence are now a normal part of many elections on Earth. It sounds like there’s a slippery slope there. I assume your notion of

freedom of speech doesn't include the right to shout 'Fire!' in a crowded theater, does it?"

"Certainly not."

"Because a lot people feel the current political processes on Earth are little different. Heck, if you have a billion bucks, you can even pay for marketing experts to advise you what the most efficient way of shouting 'Fire!' is, and then you can pay for the ads. And you can campaign to get people from your own ethnic group elected instead of people from other groups. Do you favor ethnic competition for elected positions?"

"That would be quite dangerous, here."

"It sure would, wouldn't it? We need to trust each other and work together. Thank you, Ramesh, for your testimony. No further questions."

Indira headed back to her seat. Ramesh started to rise, then looked at the justices.

"Not yet, we may have questions," said Silvio. "Actually, I'll start. Ramesh, am I to understand that when you say you expressed your political opinions to Anne Hollingworth, Siddharth Swaminathan, Lal Shankaraman, and Ichiro Otsu, that you do not deny that you asked them not to vote for Will Elliott and to vote for Lal instead? Do I understand you correctly?"

Ramesh hesitated, then nodded. "That is correct, your Honor."

"Thank you. And your defense is that, rather than stripping you of your right to vote and be voted for in this election—or maybe even some future elections, since the law does not set a limit on how long we can strip you of election privileges—instead we should declare the anti-campaigning laws unconstitutional?"

"That is correct."

“Okay, everything is clear to me. Alexandra? Gao?”

“No questions,” they both said.

“Very well, this court is now in recess.” Silvio banged his gavel and the justices rose to leave their room.

There was silence in the great room in Ceres for a moment as everyone watched.

“Wow!” said Clara.

“The nerve of him,” said Jack Alberghini. “What’s his problem?”

“There are a lot of people who hate the anti-campaigning law,” said Adam Haddad. “It’s still controversial.”

“It is, but the opposition is 10 or 20% of the population, not 49%,” replied Helmut. “Ramesh is extremely jealous of Will Elliott, too, according to my father.”

“I’ve heard that, too,” said Adam. “A lot of this is a long-standing vendetta.”

“I’m afraid so.”

“I hope they ban him for several elections, not just one,” said Clara.

“He needs to be made into an example,” agreed Adam.

“Gandimohan, we are going to *so* miss you,” said Amy. “I don’t know how I would have juggled so many things and parented Willie and kept a marriage going without your advice.”

“You’re very kind, but you did fine and I’m sure you will continue to do fine.” He looked at Willie sitting at the table between his parents. “I’ll be sure to follow him on your Facespace pages. He’s coming along so well.”

“Have a good trip, Uncle Gandimohan,” said Willie. “Say hello to my grandpa when you get to Mars.”

“Oh, I will, you can be sure of that.”

“And you’re definitely going to Uranus?” asked Marshall.

“Yes, it’s definite now, and I will help with crew screening, even during the flight back to Mars. Anyone here who wants to go to Uranus should consider it quite seriously. The next return flight to Mars in 2077 will get you back in time, and the current launch plan will send the expedition past Jupiter and Saturn on its way to Uranus; we’re very lucky the alignment is pretty good in 2078 and 2080. If enough people want to join the expedition, we’ll fly a caravel along to drop off replacement crew, and a caravel here can fly out to join the expedition as it heads to Uranus.”

“And Yuri doesn’t mind you telling us this?”

“No, he knows. It’s important that the flight out drop off and pick up people at Jupiter and Saturn. It’ll help tie the three settlements together. There are people here who have valuable experience for a Uranus settlement.”

“Construction will be tricky,” noted Marshall. “The crust includes nitrogen ice that can convert to gas.”

“It’ll be much harder than here. But an experiment at the north or south pole of one of Saturn’s moons, where it is just as cold, will be very helpful in figuring out how to do it.”

“We’ll schedule that for next year,” said Sridhar Pradhan, who was sitting at the table a few seats away. “So, Marshall, any idea what your dad thought of the Ramesh incident? I haven’t heard him say anything.”

“I haven’t seen anything, either, and I haven’t asked him,” replied Marshall.

“With a 3-hour round trip communications delay, we tend not to talk about things like that. What have you heard from your cousin?”

“Nothing, but we can be sure that Ramesh is ashamed and furious. No participation in elections for at least three election cycles and probation for two more: he got what he deserved.”

“I doubt people will vote for him even then,” said Amy.

“I think we should remember that Ramesh is an extremely bright, capable, and creative man,” exclaimed Gandimohan. “He is a natural leader. Let’s hope he develops the skills and maturity to express it effectively in the Martian cultural context. Some of this is a culture clash. It’ll take time for people to adjust to this new approach to selection of leaders.”

“Some of it is indeed a cultural adjustment,” agreed Sridhar. “But some of it is egotism and jealousy.”

“And that requires maturity,” pressed Gandimohan. “Let’s not talk about Ramesh.”

“Good luck with him when you get back to Mars.”

“When I get back to Mars, I’ll be focusing on the problem of building a community of 300 to 500 human beings to travel 3 billion kilometers and settle an entire new planetary system. It’s a fascinating and complex problem. I was very involved in the creation of the community here and I’ll be centrally involved there. It’ll be the biggest challenge of my career. When the Uranus settlement is set up and launched permanently, after a decade or so I’ll retire to Mars.”

“Where we will see you again eventually, I think,” said Amy. “Titan is no place for a retirement home.”

Just then, Johnny Lind walked by their table, heading to the desert table. Marshall stopped him and stood up. “Johnny, I’m sorry you’re leaving. I want to wish you a safe voyage back to Mars and good luck with your subsequent plans.”

Johnny smiled. “Thanks Marshall.” They shook hands. “I don’t know what I’ll do after I get back. We’ll see what Tad wants to do after college and graduate school. Mars and the Asteroid Belt Commission are sending out a lot of missions to asteroids now; maybe I’ll put in to command one or two. Or maybe we’ll apply for a stint on Mercury, or even Venus.”

“And there are lots of nooks and crannies on Mars that need exploration.”

“Yes, did you hear about the twenty kilometer long lava tube on Arsia Mons a team is exploring? There are plenty of surprises in this solar system of ours.”

“That’s for sure. I’ll be looking for more surprises right here on Titan.”

“Are you satisfied with this new exploration structure? It seems rather bureaucratic, for a small settlement like ours.”

“Yes, I think it’ll work out fine. It’s a good idea to have an overall coordinator of Saturn system exploration, and Andries is really good at fund raising. Teresa will coordinate exploration of the moons, I’ll coordinate exploration of Titan, and Sydney will coordinate study of Saturn itself.”

“The expansion of our attention on the planet itself is important, too. See you on Mars some time, Marshall.”

“Undoubtedly. Godspeed, Johnny.” They shook hands again, then Johnny continued on to the desserts.

Yuri Severin rose from his table at the front of the room and tapped his glass with a fork. “May I have everyone’s attention please,” he said. He waited for the crowd to quiet. “Well folks, here we are; 523 human beings, the entire population of the Saturn system, all in one room, and tomorrow 38 of us leave for Mars on the *Beagle*. Last month we were delighted and honored to receive 120 reinforcements, and today we are deeply saddened to see some of our dear friends of the last five years head home. We are very grateful for their fellowship, their contributions, and we will miss them. We are sure they will go down in history with the rest of us as founders of this new community, perhaps as co-founders of a new nation.” He paused after that remark, and everyone pondered the possibility, for no one knew what lay ahead of the Saturn settlement.

“We are very excited about the future possibilities. Andries Underwood is our new coordinator of exploration. On the flight out he contacted a dozen space agencies and laid the groundwork for new research grants involving university scientists in those countries and our researchers, an effort that will net us tens of millions of redbacks over the next three years. Over the next two months we will be drawing up a plan that balances and prioritizes our exploration efforts. Simultaneously, our expanded environmental management and construction teams will be developing plans for their work. We will also be drawing up a three-year plan for the spaceport, the school, the hospital, and our branch campus of Martech, and a longer, more speculative eight-year wish list of developments we’d like to see. When we finish the planning process, on the last Saturday of November we will hold a ‘Future of Titan’ meeting to talk about the plans to develop this settlement.

Then on the first Saturday of December we will vote for the Saturn Council, which will be enlarged to five members, including the Chief Executive.

“So we have a fruitful and exciting period ahead, capped by the renewal of our government. I look forward to working with you to move our knowledge of the Saturn system forward and move our community forward at the same time. Thank you for your service to these efforts.”

Passing the Torch

Nov. 2073

Willie Elliott was up with the sunlight. The light coming from his artificial window was rapidly brightening when he awoke. The four year old was momentarily frightened by the strangeness of the place, but then he remembered: we're at the new cottage!

He bounded out of bed and literally flew into the air, unused to waking up in Titan's weak gravity. He sailed awkwardly across his small bedroom and landed on the carpeted floor nearby, fortunately missing several plastic toys. "Wow," he said, unsure whether to laugh at the experience or look for scraped skin. But he felt fine, so he stood up—more carefully—and walked out of his bedroom for his mom and dad's room.

Marshall and Amy were still asleep in their big bed next to the window—a real window—looking out on the greenery of N-5. Bright light streamed in from the other end of the cylinder, which was considered "east" and therefore the source of morning illumination. Willie climbed up between them and crawled under the covers, waking both parents, who snuggled with him in the warmth. Finally, he said, "let's have breakfast upstairs on the patio!" and he climbed out of bed.

"That's what the patio's for," said Marshall, getting out of bed as well. Amy rose from her side and headed for the bathroom while Marshall pulled yoghurt, fruit, jam, and butter out of the fridge and Willie ran up and down the spiral stair with bread and plates. "Be careful!" warned Marshall when the boy seemed too fast. Willie looked at his dad, laughed, and jumped down.

Marshall thought his heart would stop, but Willie understood the low gravity. He fell very slowly two and a half meters and landed on the floor.

“Don’t do that to me so early in the morning!”

“Oh, dad!”

Amy came out of the bathroom and started the water heating up. Marshall went up the stairs with the last breakfast items. The patio was chilly—he sent Willie down to fetch sweaters—but Marshall lingered on a chair to look over N-5. The back of his chair was practically leaning against the “western” wall separating the patio from the plastic bubble, which in turn was set two meters from a cliff of marble-colored ice. The far, “eastern” side of the bubble was brightly illuminated by hundred-kilowatt bundles of light-emitting diode lamps shining on the sky-painted white and blue ceiling; the lamps along the middle of the cylinder had reached full brilliancy and even the ones at his end had started to glow. The far side of N-5, like his side, had a row of eight “cottages” across the end, each four meters wide and nine long, with rooftop patios of the same dimensions. He could see some of the windows of the cottages across the way, but most were hidden behind bushes or curtains of camouflage-colored cloth. Some people had bought additional rooms in the level below, for there were three levels of offices, labs, and horticultural spaces underneath N-5’s open-air park. The grass and flowers were well established, but the trees and shrubs were still small. Canaries were singing and he could see rabbits running around. It was quite pleasant.

Willie ran up the spiral ramp with sweaters and they both put them on. Amy followed with a pot of tea, so they started to eat. “Dad, why can’t we live here all the time?” asked Willie.

“So, you like the cottage?”

“I *love* it! So much space!”

“But you boys scared the rabbits half to death yesterday,” said Amy. “No more of that game.”

“We won’t, now that we know where they hide!”

“To answer your question, we’ll spend Friday night through Sunday afternoon or maybe even Monday morning here, most weeks,” replied Marshall. “We can’t be here more because of the low gravity, which isn’t good for any of us, but especially for you.”

“Oh, it’s fine!”

“Leave that to us,” replied Amy. “Here, let me spread jam on your bagel.” She took it and spread the jam.

Marshall looked around. “I can buy rose bushes, right?”

“Yes, six varieties, but they’re expensive and demand is really high right now. Your dad loves his roses.”

“That’s why I want some. We’ve got room here for tomatoes and all sorts of vegetables. We can spread them out when we’re not here and push them together when we are.”

“You do the work! I do horticulture fifty hours a week already! But we’re hoping everyone will raise food on their patios; it’ll take some strain off our systems.” She handed Willie his bagel and he started to eat eagerly. “Slow down,” she admonished him.

Marshall looked at the walls on the northern, southern, and western sides of the patio. “I’d like to plant climbers against the walls, too; peas and morning glories.”

“Cucumbers, squash. Even tomatoes will work.” Amy pointed to the southern wall and lowered her voice. “It’ll increase sound proofing, too.”

“They aren’t as quiet as Soo and Guangya,” agreed Marshall. Their friends the Kwoks had the unit north of them and practically whispered when on their patio. “It’s this thick air; it transmits sound really well.”

Amy sipped her tea carefully, because it was still very hot. “So, what was that late-night call from Yuri?”

“You were asleep when I finished talking to him,” he said by way of apology for interrupting the afterglow of their lovemaking. He smiled. “The Saturn Council met yesterday afternoon and he was implementing some of their decisions. They approved his recommendation that I be appointed first Chancellor of the Titan Campus of Mariner Institute of Technology.”

“Really?” Amy leaned over to kiss him. “Wow! You, rather than a dozen older scientists and scholars!”

“Well, I got the plans started, and a lot of the others didn’t want it. They checked with Andries, for example, and he said no. Most people want to focus on research and publishing, not bureaucracy.”

“Or resolving clashes over research funds, resources, and priorities.”

“I’m not sure how well I can do that, since I’m one of the younger scientists. But it does mean we need to make a decisions about the 2077 return flight. We haven’t said we’re staying. We could return to Mars five years later; 2080.”

“We could.” She looked at Willie. “And it means if we want another one, we need to start planning.”

Willie looked at her cryptically, but Marshall nodded. “It’s time to start.”

“Start what?” asked Willie.

“Never mind,” said Amy. “Acheron will be finished—really finished—in a few months. The horticulture’s set up, the additional ecology spaces will be planned and ready to be set up, industrial processes are established, exploration’s moving along . . . humans are here permanently.”

“More importantly, the solar system exploration plan is set, the space transportation system has reached a new level of capacity, the wars on Earth are over, and the U.S. and China are entering the Grand Union in 2075. Saturn is no longer sitting at the end of a fragile supply line. We’ll get supplies every year or two from either Earth or Mars.”

“We might not even be the farthest outpost much longer, with the Uranus mission scheduled for launch in 2080. Yes, this place is solid, now.”

“Are you talking about going back to Mars?” asked Willie.

“Eventually; we’re staying here for a while.”

“Whew!” said Willie. “Why should we go to Mars?”

“That’s where I was born, Willie, and grandma and grandpa are there. I suppose we’ll go back there eventually.”

“At least he’s going to get a good education here through high school,” said Amy.

“But what will you tell your dad and mom?”

“That our commitment has been extended. They’ll be disappointed, but they’ll understand.”

“When are Marsian elections? Later this week?”

“Three days. I wonder what dad will do. I don’t think he wants to be Chief Minister any longer.”

Just then they heard a clatter and a whooshing sound. They turned southward and saw their neighbor, Toru Takahashi, take off with his pair of wings. “Morning Toru,” said Marshall, looking up.

“Morning, Marshall,” he replied. He turned and flapped to gain altitude, then began to glide across the length of the cylinder.

“Doesn’t he remember the rules?” mumbled Amy, “No flying before 9 a.m.! People are eating breakfast on their patios and might not be dressed decently!”

“Well, that’s just one problem with the Takahashis.”

“Hey, Willie, are you over there?” called Yam-kuen, the 4 ½ year old son of the Kwoks. He had heard them talking from the other side of the wall.

“Morning Yam-kuen, wanna play?” called out Willie, looking at his mom. Amy nodded.

“Yes, I’m done with breakfast.”

“Me too!” Willie grabbed the remnant of his bagel and stood up. The western side of their patio had a gate that opened to a steep, grassy slope that led down to the main park area. He opened the gate and ran down the slope at the same time as Yam-kuen. The two boys dashed across the park as fast as they could run.

“Look at them go!” said Guangya, from the other patio.

“Makes you wish you were young,” replied Marshall.

Will looked up the steep, forested slope of Layercake Mesa. “So, should we go up?”

“Yes! Yes!” exclaimed the twins Jason and Shayda simultaneously.

“No way you guys can climb all the way,” said Mike.

“Carry us!” replied Shayda. She really said “cawwy”; at three and a half, she couldn’t pronounce some sounds very well.

Mike looked at Will, who nodded; three year olds weren’t heavy in Martian gravity. “But you have to walk first,” Mike replied to Shayda. They left the sandy beach along Baltic pond, where they had finished a sand castle, and headed up the grassy ski slope toward the top. “Let’s take the trail; it’s not as steep,” suggested Will.

The twins ran ahead. The trail twisted around boulders as it switchbacked up the slope. Under the growing fir trees it was cool; the tumbled rocks made little caves to explore unless there were spider webs across the openings.

“You know, when grandpa and grandma first came to Mars, this slope was range; cold, no oxygen, no life,” Will said to Jason as he came out of one little cave.

The boy looked at him, uncomprehending, and ran after his sister, who shouted to him. “They’re too young to understand,” said Mike.

“Not quite three and a half. Plenty of time.”

“They can talk pretty well for their age,” said Mike. “Though not as well as Willie.”

“He’s amazing,” agreed Will. The kids had gotten pretty far ahead of them, so Mike and Will jogged to catch up.

“Carry me now,” said Shayda to her grandpa.

“I guess that’s as far as they’ll go,” said Will. He picked up Shayda and put her on his shoulders. Mike picked up Jason and they continued up. “I love this place in spring

and early summer,” continued Will. “The smells, the wildness . . . it was worth the investment.”

“It’s very popular,” agreed Mike.

“So, how’s the article on early Noachian magnetic stripes?”

“I’ll be done in another week, then I’ll get some peer reviews; do you want to read it? I’m scheduled to deliver it at the International Mars Geological Conference in February.”

“Sure, though paleomagnetism’s not my specialty. Talking to you has helped me keep up with the field, at least!”

“You know it better than you think! So, next month, are you going to have more time to do geology?”

Will looked at his son in law, surprised, then looked around to see whether anyone was close by. “I hope so. I’m tired, Mike. I’m 72 years old.”

“Thirty-eight annums.”

“Whatever; I don’t count in annums yet.”

“Not many people do. But . . . ‘tired?’ I find that hard to believe. You’re still energetic, and you enjoy the work!”

“That’s true. Maybe I shouldn’t say ‘tired,’ then. It’s time to move on and let someone else be Chief Minister.”

“Who? There’s no one who can fill your shoes.”

“I don’t know who, but that isn’t the point. It’s not good for Mars that one person runs the place for life. I’ve been in charge of this place, more or less, wearing different

hats, for thirty-four years. I need to step aside and let others do the job. I'll have plenty to keep me busy. I need to write my memoirs and earn back some of the fortune I lost."

"Since when have you ever worried about money? I wish you'd reconsider, dad; I really do. I think what you can offer is unique. It's irreplaceable."

Will was surprised Mike had called him "dad"; it was the first time. "I don't agree. Besides, my health may not be good for two more annums. I've already had cancer cut out of me."

"That took one sol."

"I didn't recover *that* fast. I felt my age, Mike."

They didn't talk any more about politics. In a few minutes the winding trail reached the cliff at the top of the slope. They put the kids down so they could climb up the narrow stairs; Jason and Shayda ran up them, which momentarily frightened Mike. Mike and Will followed more slowly. "Wow!" said Jason at the view. It wasn't clear whether the expanse of Aurorae Outpost or the wild range and dramatic northern escarpment had impressed him more.

"It's beautiful," agreed Will, and he felt a surge of emotion when gazing at both the natural and artificial environments.

"What's that?" asked Shayda, pointing at a huge construction area several enclosures to the west.

"Atlantic," replied Will. "The biggest habitable enclosure yet; 1,000 meters wide and 1,200 long. You see the lines of pillars down the middle? That dome will be so big, it'll need three rows of restraining cables in the middle."

“Every construction director who comes here says we need to stop building bigger enclosures, then he or she builds a bigger enclosure,” observed Mike.

“It’s the big temptation, and they are cheaper per square meter.” Will pointed to the escarpment. “I wonder whether, in the twenty-second century, we’ll try to dome over the entire vallis. Maybe not here, where it’s several hundred kilometers wide, but farther west where Marineris is narrower and deeper, who knows?”

“What about terraforming?”

“That’s for the twenty-third century,” replied Will, chuckling.

They admired the view and let the twins run around the crest for a few minutes, then started down the ski slope, which the kids ran down. At the bottom they entered Baltic Dome and caught the automated bus from Baltic Square to Andalus Square. When they entered the square, Jason said, “ice cream! Ice cream!” and his sister joined in the chant, so they walked into the Gallerie. It was fairly busy; it was a Sunsol afternoon. As they sat at the ice cream store and ate their dishes of vanilla, Skip Carson came by with his young assistant. “Hey, Skip, good sol,” said Will.

“Good sol. Out with your grand kids?”

“We hiked to the top of Layercake Mesa in South Baltic Dome.”

“Oh, how fun.”

“I’m sorry I haven’t had time to welcome you back since you returned last week, Skip. It’s good to have you around again.”

“Thanks. This time it’s permanent; or maybe I should say I am now a Marsian citizen and will commute to Earth occasionally for a movie contract, but I consider Mars

my residence, not Hollywood. This is a much more pleasant place, I like the scale, and there's a feeling of progress, of purpose, I find wholly lacking in the USA."

"Really? With the United States joining the Grand Union and enacting a series of new laws to accommodate the new international order; those are big changes!"

"They are, and they're remarkable, but Americans aren't committed to them. They're making the changes because they're traumatized, because they lost a war, because the dollar has been dethroned as the world currency, and because they no longer can boss around the rest of the world. They've been humbled and don't like it. They may even change their minds and try to reject the Grand Union. It'll be a generation before this change is fully accepted, and meanwhile we can expect a big conservative backlash. Mennea will go down in history as a great President, but he'll probably be followed by an arch-conservative who will try to roll back as many of the changes as possible. It'll be the next century before the U.S. adjusts to its new role in the global affairs. That's my feeling, and it makes me profoundly sad. I'd rather be here making movies and documentaries because this place is the future; it's the new America."

"We have a ways to go to achieve that! At the end of this columbiad we might have a population of 15,000!"

"It's not a question of size, but of influence; but you know that. Write your memoirs and I'll interview you. Wait and see; you'll magnify our voice. Unless, of course, you're staying on as Chief Minister."

Will smiled. "No comment, Skip. Not before an election; I don't want to prejudice any votes."

"Fair enough, Will. The vote will be over tonight."

“And I have a big public event scheduled for morrowsol. Maybe that will be a good place to say something.”

Skip nodded. “Maybe it would. By the way, have I ever introduced you to my assistant, Briana McKay?”

“No, you haven’t.” Will extended his hand. “Pleased to meet you. Welcome to Mars.”

“Thank you.” Briana shook his hand. “I’ve only been here a few weeks, but I already love this place! Skip has showed me around almost everywhere.”

“We’ve even been to Aram and Tithonium,” added Skip.

“Mars is fascinating. I’ve taken out citizenship so I could vote.”

“Excellent, we need as many talented people as we can acquire.”

Skip put his hand on her shoulder. “You should tell him about your grandfather.”

Briana smiled, a bit embarrassed. “My grandfather is former Vice President McKay. As you know, he was the loudest and angriest defendant in the war crimes trials, and he’ll be in prison for ten years. But in the last two months my father tells me that he is coming around and realizing the enormous harm he did. So, in addition to justice, perhaps the trial will do some personal good.”

“I’m glad to hear that,” said Will. “If you wish, please send him an assurance that I will keep him in my prayers daily.”

“Thank you, I’ll do that. He’s a great believer in prayer.”

“So are a fair number of us up here.”

Will watched the clock anxiously. When 2:59:59 was replaced by 3:00:00, he opened the election website. “Very interesting, as always,” said Ethel, standing behind him.

“It is.” He pointed. “Look, I was elected to the Mars Council!”

“So, does that mean the people assume you are resigning as Chief Minister and want you to continue serving in the legislature?”

“Or does it mean they want me to retire as Chief Minister?” asked Will, disappointed. “And was this the result of Ramesh’s comments during his trial?”

“It casts a pall over everything.”

He nodded. “Strange to think that being elected to the Mars Council would appear to be negative, but I wasn’t elected to the Mars Council two annums ago or last annum. The people in this district assumed I’d be Chief Minister. The pundits will go crazy over this.”

“They’re always trying to discern the will of the people.”

“Well, let’s go to bed. It won’t change things morrowsol. I know what I plan to say.”

At 10 a.m. the next morning, Will was at the Cochabamba egress facility. Dr. Jefferson Woolsey was there with his Marsoform team and a large, heavy container. Several dozen spectators were suiting up; an extra Mobilhab bus was available to transport them.

The two vehicles exited the airlock and headed up the Circumnavigational Highway northeastward for ten kilometers. When it reached “the ridge,” a long, low rise parallel to the escarpment, they stopped and got out. Jefferson and his team pulled out the container and opened it, revealing a dozen small cactars.

“Gather round,” Jefferson said, waving everyone to form a circle. He paused to wait for everyone. “These twelve cactars represent a wholly new species of lifeform, a species constructed from genes of dozens of different terrestrial species, not all plant in nature. They are, essentially, cacti modified so that their tough outer skin has become a photosynthetic spacesuit. Warmed by the sunlight, the skin conducts heat to the hollow interior, where cells grow and divide. Chemicals in the outer layer convert ultraviolet into wavelengths that chlorophyll can use; cells all the way through can photosynthesize. The oxygen produced is trapped in the cells and some is converted into hydrogen peroxide; some of the rest accumulates in the atmosphere of the cactar’s hollow center. Nitrogen fixing cells in the outer skin add nitrates. Atmospheric dust accumulates in special pores in the skin and is ‘digested’ to obtain nutrients. Others are extracted by the holdfast, a root that penetrates downward into the ground. In the polar regions where ice is present in the soil and accumulates as frost on the plants, the plants will obtain water naturally; here in Aurorae we’ll need to frost them periodically.

“Before we start to place the cactars, I want to thank Dr. Will Elliott for his enthusiastic support for this project. He has a few words to add.”

Jefferson stepped aside and Will stepped behind the container of cactars. He turned to face the cameras and waited a moment for them to adjust so that his face was visible inside his helmet. “The event we are about to witness is of great significance. Terrestrial life has inhabited Mars since the end of the Cretaceous 65 million years ago, but it has been confined to microbes in thermal areas. The natural pace of evolution is too slow to adapt multicellular plants to the Martian environment; the number of necessary mutations is too many to occur naturally. Genetic modification can do it faster and better.

“This species is only the first one we will create. It is not finished; cactars cannot survive the polar winter well and cannot yet reproduce on their own. But in the next decade those limitations will be overcome. Future species will feature a series of small tubes or arteries rather than large interior hollows and will have roots that can run horizontally and bud to produce new plants. In the next century, if the citizenry is satisfied by this experiment and weighs its pros and cons favorably, Mars may acquire an extensive surface biology.

“For me, this event represents a remarkable culmination of my career. In three months we will celebrate the thirty-eighth anniversary of the first human landing on Mars. I have had the privilege of watching the settlement of this world advance from tiny outpost to town to planet-embracing nation. I never could have imagined, on that first day, that I would live to witness such a transformation. And now we are embarking on a remarkable kind of terraformation, one that will release a small quantity of oxygen into the Martian atmosphere; not enough to kill Marsoforms, but enough for oxygen extractors to be effective. I feel blessed that this is my last major act as Chief Minister.” He paused to make sure people heard that last remark. Startled expressions on several faces indicated that they had.

“Now, let us place the cactars. Jefferson, you lead us.”

Jefferson came forward with two shovels. He and Will dug two holes. After digging a hole of about the right size and depth, Will stopped to pass the shovel to Érico. Will picked up a paper pot and placed it in the hole, then pushed the loose regolith against it with his gloved hands. He proceeded gently; the cactars had small holdfasts and could easily be knocked over.

“Mars’s first forest has been inaugurated,” he said.

Six sols later was the inaugural session of the Mars Council. The chamber was crowded; 86 representatives had to fit in it, plus the Supreme Court, the cabinet, six ambassadors, and a few special guests. The balcony and its fifty seats reserved for the public was full and had standees.

Will and Ethel entered and headed for their seats; he had a place in the area reserved for the representatives and she, as the outgoing First Lady, had a seat next to the Supreme Court. Will searched for the seat with his name until Lal pointed it out. “Right here up front, because you are also outgoing Chief Minister, just like two annums ago.”

“So, tomorrow I’ll have a different seat?”

“No, as one of our elders, you will have a place of honor up front.”

Will nodded and sat next to Lal. He seemed nervous, as well he should be; as the number two in the government and chief elected officer of the Mars Council, he was a likely successor. Will looked around and saw one seat in the front row with a still photograph of Helmut Langlais. “How are we including him?”

“Helmut doesn’t need to ask to speak; he’s watching the entire procedure, as representative of Ceres, and all he needs to do is record a comment. It will be added to the Mars Council record and if it is still relevant when we receive it, we’ll play it immediately. He’ll vote when the call for the vote is taken and his vote will be added to the total.”

“Most of the time, bills pass with more than one vote anyway.”

“Exactly.” Lal looked around. “I think we’ve got everyone, so I had better call this meeting to order.” He rose, walked to the chairman’s podium in front of the chamber, and banged the gavel. “This 4th Council of a free and independent Mars is called to order. Ladies and gentlemen, I want to welcome all of you to this exciting and historic event. Mars is larger and more capable than ever. Humans are expanding across the solar system and as they do so, they are adopting our governing system, our educational system, and forms of our culture. We have much to be thankful for and this sol we look toward the future with confidence and hope in our hearts.

“We are gathered this sol to fill three positions by election: Chief Minister of Mars, Chair of the Mars Council, and Clerk of the Mars Council. To do this, we need tellers to count the votes. The names of our tellers have already been circulated by email and no objections to them were raised. Are there any objections to the names now?” He looked around and no one spoke. “Excellent. But before we turn to the voting, outgoing Chief Minister has asked to speak to us briefly. Will Elliott.”

There was strong applause as Will stood and walked to the podium. There was a tear in his eye as he nodded to everyone in thanks. “If there is one thing I want to say to everyone, it is thank you. Thank you for your sacrifice for Mars. Thank you for setting aside strong opinions and ideas in order to join in unity around another’s idea, one that becomes government policy and the focus of our community’s efforts. Thank you for your patience and restraint in expressing your ideas and in your openness to the ideas of others. Thank you for your trust and confidence in our new form of government and in its elected leaders, including myself. Thank you for devoting your energy and treasure to the development of this world. Thank you for your willingness and ability to change

yourselves so we could build our new world with a remarkable level of unity and unanimity.

“These are not trivial matters or accomplishments. The moments when human communities achieve high levels of unity are very rare. Revolutions and wars are usually the cause. I do not anticipate that we will always maintain our unity at a high level; there will be crises. The keys, I think, are two. First, we must restrain our discourse so that it is dominated by trust, patience, openness to ideas, and detachment from our own pet ideas. These principles of consultation will make it possible to achieve the second key: a clear direction for our community and nation. People will sacrifice when they have a sense of purpose and direction. Earth is crying out, first, for the ability to achieve consensus over the direction society should move in, and second, for lack of such a direction. Without a direction, people feel free to serve themselves first and worry about the community much less.

“One reason over four hundred thousand people applied to come here, this columbiaid, is because we have a direction. But our ability to have a direction is not dependent solely on surplus mining income. It is also dependent on our unity on how to expend that surplus. We have immigrants rather than consumer goods. Yes, we need more consumer goods. Yes, we want a more comfortable life for our children. But let us balance consumer goods with projects like settling the Uranus and Neptune systems, developing the asteroid belt, and spreading human communities across the face of this world.

“Ultimately, we are building a new civilization. This is the primary reason to spread human beings across the solar system; otherwise we could stay on Earth, go to

ever larger malls, and do our research robotically. That new civilization will be the fruit of our sacrifice, and I don't just mean sacrifice of our treasure; it will be the fruit of our sacrifice of ego. Our patience, our openness to others, our detachment from our own pet ideas, our listening skills, our sense of fairness and justice for all, and above all our sense that we must maintain a high level of unity: these are the keys to maintaining a direction and purpose for our society. They are also the key to our choice of leaders at every level in our society, from the voting citizen to the votes we are to cast this sol. They will be our challenge, every sol, every annum, into the future. But they are challenges we will face together. Thank you, everyone."

Will walked back to his seat while the audience gave him a standing ovation. Will sat, then stood and acknowledged the applause. He glanced at Ethel, who was thrilled by his speech. He looked up at the public balcony and saw Ramesh, standing as well, and he nodded at Will when their eyes met.

The applause waned, then stopped, and Lal rose. "Could the tellers come forward and instruct us about the first election?"

The tellers rose and came forward. Will found himself unable to pay attention to their instructions, which he knew anyway. He was drained from the effort to deliver his remarks, which had been partially spontaneous, and he was filled with a swirl of thoughts and emotions; what the transition in leadership would mean for Mars, what it would mean for him, what he would be doing morrowsol, who would take over now, and what challenges he or she would face. So many huge unknowns.

The tellers began to remind everyone to vote using the old-fashioned pencil and paper in front of them, to vote for anyone on Mars who they felt had the necessary

qualifications, etc. Will pulled the square of paper forward on his desk and picked up the pencil.

Silence.

He lowered his head to pray and at first no name or face came to mind. But in a few seconds, his old friend John Hunter came to mind. Why, he wasn't sure, and no one else would ever think of voting for John; he had served one term on the council years earlier, and not since. So he wrote down that name. Then the tellers came around to collect the ballots and retreated to a large table at the front of the room where they began to build piles of ballots by name. Everyone waited patiently, in near complete silence.

After a few minutes of counting, chief teller John Stanwood stepped forward. "We do not yet have a Chief Minister, whose election requires at least 44 votes out of 86, so we will need to conduct another round. The votes are as follows: Lal Shakaraman, 29; Jacquie Collins, 21; Lyle Quincy, 14; Érico Lopes, 7; Will Elliott, 6; Emily Scoville-Rahmani, 5; Vanessa Smith, 3; John Hunter, 1."

"I have retired from public service in that capacity," exclaimed Érico immediately.

"As have I," echoed Will.

"Let us remember that in the next round," exclaimed Lal. He sat next to Will, who could feel his nervousness.

Will pulled the ballot forward to write a name on it. He was struck by the fact that Lyle Quincy, the Council's Clerk and number two, had come in third, and that Jacquie Collins, a member of the cabinet and no longer a member of the Council at all, had come in second; indeed, not that far behind Lal. Her highly effective service as Clerk of the

Council had been remembered. Indeed, she had vision, unlike Lal, and had a better control over her ego than Lyle. He penciled in her name.

The tellers collected the second round of ballots and announced the result. “We still do not have a Chief Minister,” said Victor MacLeod, one of the other tellers and representative from Aram. “The vote is as follows: Jacquie Collins, 35; Lal Shakaraman, 32; Lyle Quincy, 12; Emily Scoville-Rahmani, 6. The total is 85 because the Ceres representative cannot vote this quickly and previously agreed to withdraw from the vote after the first ballot, which he cast ahead of time. Let us vote again.”

Will pulled the third square piece of paper forward and as silence descended on the room, he prayed quickly for guidance. Then he wrote down the name of the person he was voting for and handed the folded ballot to Victor, who came around to pick them up.

The counting went quicker; the piles were fewer again. The third teller, Louise Tremblay, announced the results this time. “We are very close,” she began. “Remember, we need 44 votes for someone to be elected Chief Minister. The results are as follows: Jacquie Collins, 43; Lal Shankaraman, 39; Lyle Quincy, 3.”

There were murmurs in the room over the announcement. The votes for women cabinet members had become consolidated in one person; the votes for a Mars Council officer had not yet coalesced. Louise announced a fourth round. Will pulled another square of paper to him, closed his eyes to pray briefly, then voted. He looked around the room and was struck by how many people seemed to be praying or meditating about the choice before them.

The ballots were collected and this time, they were piled into two separate accumulations only. They recounted the results, nodding when the results agreed. John

Stanwood stepped forward with a smile. “We have a new Chief Minister: Jacquie Collins, with 51 votes. Lal Shankaraman received 34 votes.”

The Mars Council rose to its feet for an ovation. Jacquie, seated with the Cabinet officials and Supreme Court members, rose on shaky feet; Ethel, seated near her, rose to help her. She was clearly shocked and overwhelmed; and that was how it should be. Several people near her hugged her and tears began to stream from her eyes. Finally, she made her way to the front of the room.

“I am speechless,” she began, and for several seconds she was. “This most unexpected vote of confidence by my peers presents me with an enormous challenge, not only of responsibility, but as Will Elliott has noted, of personal character. I am tremendously unworthy of the office to which you have called me. But with your help and support, I will endeavor to keep Mars moving forward.”

There was more applause. Will rose and walked to her. He embraced her and raised her hand in the air. “Our new Chief Minister!” he exclaimed. Then he began to sing, and everyone joined in:

*This land is your land, this land is my land,
From the Hellas Basin, to the cratered highland,
From Tharsis Montes to the Mariner valleys,
This land was made for you and me.*

*As we were ranging across his deserts
Along his channels, o’er gleaming ice caps,
We fell in love with his ruddy vistas
This land was made for you and me*

*As we were walking along the cliff edge
We saw above us, the twin moons shining
We saw below us the Aurorae Valley
This land was made for you and me*

*We were prospecting Dawes to Cassini
Dug golden riches in Meridiani
Found nuggets plenty in Thymiamata
This land was made for you and me*

*As I was flying toward Phobos beaming
To build ships valiant, fill sailers gleaming
I glimpsed a red globe, my cratered homeworld
This land was made for you and me*

*We've flown from terra to the dusty red ball
To build a country with justice for all
To found a new home, a city of the free
This land was made for you and me*

*Marsians are moving, Marsians are talking
Calling for justice, voting for freedom
And all around us the feeling's growing
This land was made for you and me.*

1. Operating Close to the Edge 3
Dec. 26 2070- Jan. 2, 2071
US indicts former President and Vice President for war crimes. Roger and Érico debate the implications. Will and fellow geologists go check out hydrothermal power possibilities of Likoma Facula. Roof collapse in N2 requires emergency response. Jan. 2071: Yevgeny reports a lot of people returning to Earth, but his sister reports things are looking up. Magellan wants to go back to Venus, even though they haven't reached Mars.
2. Resupply 25
May-June 2071
The first supplies arrive on Mars from Earth. Will meets the Chinese ambassador and discussed a contract for robotic road and pipeline building equipment, plus a launch contract.
3. Changing Priorities 48
Late August 2071
Ramesh meets with Kristoff and Lisa about Ukraine enclosure and compromises with his plan to allow full pressurization; the *Korolev* lands on Titan and Yuri tells Johnny he'll go back up with a smaller crew and two caravels; Will talks to Tree Rivers, who wants support for his caravel and talks of plans to terraform an asteroid; he also sees Jacquie Collins in Silvio's and they talk about her vision for expanded legislation.
4. The Prize 65
Early October 2071
José Suzuki gets the physics prize; Vanessa Hunter, the physiology prize; Will and the diplomacy team the peace prize.
5. Firebomb 80
Early December, 2071
Saturn watches the Nobel prize ceremony; Tang and Will talk; Will and cabinet plan opposition of 2074; Wolf arrives on Ceres.
6. Hard Place to Love 101
February 2072
Chinese ambassador opposes immigration plan; drone attack on White House; supplies launched to Saturn from Earth, late January or February 2072 (best time and after Mars anyway); Saturn debates the future; Charles Vickers and Will talk, Charles is on his way back to Mars in late 74.
7. To Live is to Love 117
mid-March 2072
Mennea and Will exchange videomails; Molly arrives and is depressed; Tree talks to Ramesh about enclosing an asteroid; Will takes Molly for a walk and tells her Mars needs people who care about others; Will worries with Érico about Saturn; Green World community caravel arrives with 200 and Will talks to Tree Rivers about it.

8. We Do Space 144
May 2072
Marshall, Amy, and Willie visit S-1, the general store, and the site of their future cottage; Will goes to Madhu's retirement and talks to Yoshi about Japan's role; Zhao Tao meets with Will to complain about Marsian dominance of space and Will resolves to do something about the matter; Johnny Lind returns to Acheron and consents to use of the caravels for Titan exploration for six months, as he plans to leave on the *Cassini*.
9. Ministry of Space Exploration 164
June 2072
Will meets with Jacquie Collins, Xiaopeng, asks them to establish a new ministry; Marshall visits Ontario Lacus; Kristoff asks for the rest of Ukraine; Charlie Langlais leaves Ceres; Will publishes anonymous editorial about space settlements becoming temporary Mars boroughs.
10. Ice Crystal Cavern 182
July 2072
Molly and Cecie set up Molly's new apartment and talk about Bahá'í idea of God and revelation; Acheron celebrates with dinner in N-7; Helmut and Sebastian talk about extra-territorial borough status; Will, Jacquie, Xiaopeng meet with Ambassador Danforth about US-Mars partnership.
11. Difficult Decisions 203
Early Sept. 2072
Yevgeny, Emily, Henry, and Yuki meet with Will because the immigration plans for 2073-74 are in chaos; the Ceres Council meets to finalize the Extraterritorial Borough Resolution; Will meets with Brian and they decide to call a Solar System Summit; Klaus Richter calls Will to tell him they are shutting down Caloris Station; Ambassador Zhao calls to condemn the Ceres Resolution; Molly, Ethel, Liz, Mike, and kids explore Caribbean and Mediterranean; Will and Ethel talk after the employment summit and they discuss postponing the election.
12. Solar System Summit 232
late Oct. 2072
Summit held simultaneously in Aurorae, Beijing, Houston; US and Mars reach a mutual exploration agreement.
13. Ceres Resolution 255
Early Nov. 2072
Will gets a tour of the cactar facility; in Cassini, he is lobbied to develop the Central Highlands and asks about Ceres; Will and Helmut talk, then he talks to Rodrigo and Carter in the Gallerie; Johnny Lind and others debate the Ceres resolution on Janus; Hollingworth opposes in the Mars Council; Kurt is hurt; it is approved by Council but

requires a Constitutional amendment; Mars celebrates and they discuss US politics as Mennea is reelected; Will agrees to propose Helmut Langlais ABC commissioner

14. Steps Forward 317

Mid December 2072

The Prometheus shuttle is first launched to Earth orbit and Mars celebrates; the *Wolf* lands on Lutetia and Helmut watches and talks to Carter Levine at Uzboi; Johnny Lind's crew returns from the rings, Marshall goes to see Titanus Lacus, and the Acheron population debates and rejects borough status; Jacquie Collins and associates negotiate with the American and Chinese ambassadors about Ceres, Jupiter, and Saturn; Helmut is appointed Commissioner.

15. Commander, Mayor, and Commissioner 310

Early January, 2073

Will admits to Mike he wrote the extraterritorial piece and they discuss the Constitutional amendment, PGM supply/demand, and Ceres's scientific collaboration proposals; they meet Nigel Stanfield, who is reopening the American Martian Antarctic base; Helmut receives an email from Titan expressing desire to sell nitrogen to them; Carter Levine reports improvements in Cererian PGM extraction and says he wants to come; Quentin Pauwels is hired to serve as ABC agent on Earth; Pauwels proposes ways to approach nations; Helmut calls Belgian space agency head, Pierre Dumont; Will and Helmut exchange videomails; US calls for reorganized UN and Mars as a member; Marshall calls Will, he's been appointed Dean of Titan's Martech campus, and he calls them all Mariners; Will uses the term in his New Year's message;

16. Constitutional Amendment 327

Jan.-Feb. 2073

Constitutional amendment passes and Ceres adds a stanza to This Land is Your Land; Will calls with congratulations; Will and Ramesh explore Mediterranean and Will orders an audit of the new designs; Carter Levine reports to Helmut about Parenago's plans to double production, shift to Prometheus launches, and export nickel and cobalt; Belgium agrees to a mission to Hygeia and Nigeria to Eunomia; Tree talks to Ramesh further about terraforming an asteroid; Marshall returns home and Amy announces the plan to expand horticulture 300% and she is now in charge of bioarchive; Ramesh meets Lal and suggests he start campaign for Chief Minister, and volunteers to talk him up secretly; Ramesh describes a new plan to terraform an asteroid.

17. PGM Rush 355

March 2073

Charles Langlais and Firuz Moulin talk about Lutetia, geology, and life; trans-Ceres injectin occurs and Will discussed conicals, PGM rush with cabinet members. Orders for the Prometheus shuttles; Roger and Érico have their last argument and Roger drops dead; discussions at the wake; at State Funeral, Ramesh asks Rajan to vote for Lal.

18. Truth and Faith 375

April 2073

Sam, Mindy, Mike, and Liz go picnic with the kids in Congo and discuss Thaumasia, the shadow of the first generation, faith in oneself, and Bahá'í classes; Rachel and Will meet to review the new safety guidelines; Greg and Karol talk about politics on Earth and talk to Molly about elections and classes; Molly and Devika talk about Bahá'í classes.

19. Safety Guidelines

396

June 2073

SS-4 cavern hits a small chunk of ataxite; Ceres discusses the new safety guidelines very positively; Ramesh is furious about the safety guidelines and discusses campaigning against Elliott with Lal and Siddharth and they are shocked that Devika has become a Bahá'í; Will talks about the safety guidelines with Mike and family, and Mike reports about Mercury's situation and he's been accepted for the Gradivus mission and Ethel announces she's retiring.

20. Arrivals and Departures

412

Aug./Sept. 2073

Will had pancreatic cancer cut out of him and has visits from Father Greg, Andersons, and talks to Sam about commanding the expedition to set up Thaumasia, notes that Vega leaves for Mars next month and Castor is ready to fill up and 2 Prometheus are working; Cassini and Beagle arrive at Titan and Marshal boasts to Andries it's the best place off-Earth; Charlie Langlais arrives in Aurorae

21. Censure

432

Early October 2073

Bill Hollingworth brings his mom lunch and they talk about Saturn and why he won't go with them; Ramesh and Anne talk about development plans for Aurorae and he asks her to vote for Lal; she goes to talk to Siddharth and they agree to go talk to Silvio; Ceres watches the trial of Ramesh and hears his defense; farewell dinner for Gandhimohan and Johnny and others at Acheron, Yuri announces a three year plan and elections in December.

22. Passing the Torch

453-76

Nov. 2073

Willie has fun on their cottage. Marshall is appointed Chancellor of Acheron Campus of Martech and they decide to stay on Titan. Will and Mike take the twins to the top of layercake. Skip Carson is back permanently; talks to Will. Will is elected to the Mars Council; a sign the public is ready for him to retire. The first cactars are planted outside, Will says he is retiring. At first Mars Council meeting, Jacquie Collins is elected Chief Minister. Will hugs her and leads everyone in singing first Mars song.

Reread and edited, June 12-16, 2012 (chapter 1); material added starting June 26, 2012. Separated from volume 18 about July 12, 2012. Volume 19 and the series completed, 11:59 p.m. September 21, 2012.

Miscellaneous Notes

EM 17 Dec 2054 (Nov. 30, 2069)

Earth 5/15/69 Mars 11/15/70

Earth 8/1/69 Mars 2/1/70

Earth 9/15/69 Mars 12/15/69

Earth 11/1/69 Mars 4/1/70

Earth 12/1/69 Mars 5/1/70

Vernal Equinox March 24, 2053 (Feb. 15, 2068)

Summer Solstice: Sept. 1, 2068

Autumnal Equinox, April 9, 2054 (Mar. 3, 2069)

Dust storm season starts, May 31, 2054 (Apr. 3, 2069)

Winter Solstice: July 28, 2069

Dust storm season ends, late Aug. 2069

Vernal Equinox, Feb. 9, 2055 (Jan. 2, 2070)

Summer Solstice: July 20, 2070

Autumnal Equinox: Jan. 19, 2071

Vernal Equinox: Nov. 19, 2071

Earth/Mars opposition January 11, 2072

Earth 7/1/71 Mars 1/1/72

*Earth 9/15/71 Mars 3/15/72

*Earth 12/1/71 Mars 3/1/72

Earth 1/15/72 Mars 6/15/72

Earth/Jupiter opposition Nov. 22, 2071 and Dec. 26, 2072

Earth/Saturn opposition April 29, 2072 (so Mars/Saturn opposition is more like mid October)

Autumnal Equinox: Dec. 6, 2072

Dust storm season starts, Jan 27, 2073

Winter Solstice: May 6, 2073

Dust storm season ends, June 22, 2073

Vernal Equinox Oct. 7, 2073

Mars-Earth opposition Feb. 14, 2074

Emergency cargo flights

Earth 12-1-70 15.9 k/s Mars 5-31-71 7 k/s 180 d

Earth 1-1-71 15.6 k/s Mars 6-20-71 6.7 k/s 180 d

Earth 2-1-71 14.1 k/s Mars 8-29-71 4 k/s 209 d

Earth 3-11-71 13.4 k/s Mars 10-18-71 3 k/s 221 d

Earth 4-21-71 12.5 k/s Mars 11-27-71 2.9 k/s 220 d

Voyage of the Magellan:

Venus 8-20-70 6 k/s 154 d Mars flyby @51,484 km 1-22-71 290 d Venus 11-7-71 2.1 k/s

OR: Venus 8-20-70 6 k/s 154 d Mars 1-22-71; Mars 5-31-71 5.8 k/s Venus 11-27-71 2.5 k/s 180 d

Earth resupply: Earth 8-1-71 10.4 k/s Venus 11-1-71 3.9 k/s 92 d

Earth 5-6-71 2.5 k/s Venus 10-18-71 1.4 k/s

Earth 5-6-71 9.9 k/s Mercury 8-19-71 5.3k/s 105 days

Mars-Ceres synodic period 3 years 2.2 months

Earth opposition Ceres May 2, 2074 so Mars opposition Ceres Oct. 10, 2074 (previously calculated as late Aug. 2072) and Mars launch to Ceres in 172 days earlier (90 degrees before) or April 21, 2074. Next opposition: December 6, 2077. Previous launch window: Aug. 4, 2071.